Refine Search

Your wildcard search against 10000 terms has yielded the results below.

Your result set for the last L# is incomplete.

The probable cause is use of unlimited truncation. Revise your search strategy to use limited truncation.

Search Results -

Terms	Documents
L43 and (reduc$ with (gas$ or energy$ or fuel$ or (power$ adj suppl$)))	45

Database:
US Pre-Grant Publication Full-Text Database
US Patents Full-Text Database
US OCR Full-Text Database
EPO Abstracts Database
JPO Abstracts Database
Derwent World Patents Index
IBM Technical Disclosure Bulletins

Search: 10/777140

Refine Search

Recall Text Clear Interrupt

Search History

DATE: Monday, September 10, 2007 Purge Queries Printable Copy Create Case

Set Name side by side	Query	Hit Count	Set Name result set
	DB=PGPB,USPT,USOC,EPAB,JPAB,DWPI,TDBD; THES=ASSIGNEE; PLUR=YES; OP=OR		
L44	L43 and (reduc$ with (gas$ or energy$ or fuel$ or (power$ adj suppl$)))	45	L44
L43	L41 and (((modif$ or edit$ or chang$ or correct$) near3 (gas$ or energy$ or fuel$)) with (curve$ or chart$ or graph$))	82	L43
L42	L41 and ((modif$ or edit$ or chang$ or correct$) near3 (gas$ or energy$ or fuel$ curve$ or chart$ or graph$))	903	L42
L41	123/379;701/101,103-104,112.ccls.	2165	L41
L40	L38 and ((modif$ or edit$ or chang$ or correct$) near2 ((gas$ or energy$ or fuel$ or (power$ adj suppl$)) adj3 (curve$ or chart$ or graph$)))	1	L40
L39	L38 and koga$	0	L39
L38	L36 or L37	13	L38

L43: Entry 4 of 82 File: PGPB Nov 30, 2006

DOCUMENT-IDENTIFIER: US 20060271267 A1
TITLE: Method of controlling an exhaust gas turbocharger

Current US Classification, US Primary Class/Subclass:
701/103

Description of Disclosure:
[0015] FIG. 6 shows an arrangement for a performance graph-based pilot control with exhaust gas temperature correction,

Description of Disclosure:
[0031] With the performance graph-based pilot control under certain circumstances, an exhaust gas temperature correction may be advantageous. A corresponding controller structure is shown in FIG. 6. An adaptation of this control for the waste gate control is shown in FIG. 7. The waste gate control controls the power generated by the turbine and provided to the compressor.

<table>
<tr><td>L37</td><td>@pd<=20030214 and ((modif$ or edit$) near3 ((gas$ or energy$ or fuel$ or (power$ adj suppl$)) adj3 (curve$ or chart$ or graph$))) and (vehicle$ or car$ or automobile$)</td><td>3</td><td>L37</td></tr>
<tr><td>L36</td><td>@ad<=20030214 and ((modif$ or edit$) near3 ((gas$ or energy$ or fuel$ or (power$ adj suppl$)) adj3 (curve$ or chart$ or graph$))) and (vehicle$ or car$ or automobile$)</td><td>12</td><td>L36</td></tr>
<tr><td>L35</td><td>@ad<=20030214 and ((modif$ or edit$) near3 ((gas$ or energy$ or fuel$ or (power$ adj suppl$)) adj (curve$ or chart$ or graph$))) and (vehicle$ or car$ or automobile$)</td><td>0</td><td>L35</td></tr>
<tr><td>L34</td><td>@ad<=20030214 and ((modif$ or edit$) near3 (fuel$ adj (curve$ or chart$ or graph$))) and (vehicle$ or car$ or automobile$)</td><td>0</td><td>L34</td></tr>
<tr><td>L33</td><td>@ad<=20030214 and (fuel$ with suppl$) and ((modif$ or edit$) near3 (fuel$ adj (curve$ or chart$ or graph$))) and (vehicle$ or car$ or automobile$)</td><td>0</td><td>L33</td></tr>
<tr><td>L32</td><td>@ad<=20030214 and (fuel$ with suppl$) and ((chang$ or modif$ or edit$ or correct$) with fuel$ with (curve or chart or graph)) and vehicle</td><td>921</td><td>L32</td></tr>
<tr><td>L31</td><td>@ad<=20030214 and (fuel$ with suppl$) and (fuel$ with (curve or chart or graph)) and vehicle</td><td>4080</td><td>L31</td></tr>
<tr><td colspan="4">DB=PGPB,USPT; THES=ASSIGNEE; PLUR=YES; OP=OR</td></tr>
<tr><td>L30</td><td>(701/50 |701/81).ccls.</td><td>1312</td><td>L30</td></tr>
<tr><td>L29</td><td>((sens$ same load$ same gear$) and (tranmission with rang$))</td><td>1</td><td>L29</td></tr>
<tr><td>L28</td><td>((sens$ same load$ same gear$) same (tranmission with rang$))</td><td>0</td><td>L28</td></tr>
<tr><td>L27</td><td>L21 and ((sens$ same load$ same gear$) same (tranmission with rang$))</td><td>0</td><td>L27</td></tr>
<tr><td colspan="4">DB=USPT; THES=ASSIGNEE; PLUR=YES; OP=OR</td></tr>
<tr><td>L26</td><td>L7 and (track$)</td><td>0</td><td>L26</td></tr>
<tr><td colspan="4">DB=PGPB,USPT; THES=ASSIGNEE; PLUR=YES; OP=OR</td></tr>
<tr><td>L25</td><td>L7 and (driv$ same track$)</td><td>0</td><td>L25</td></tr>
<tr><td colspan="4">DB=USPT; THES=ASSIGNEE; PLUR=YES; OP=OR</td></tr>
<tr><td>L24</td><td>L7 and (driv$ adj2 track$)</td><td>0</td><td>L24</td></tr>
<tr><td colspan="4">DB=PGPB,USPT; THES=ASSIGNEE; PLUR=YES; OP=OR</td></tr>
<tr><td>L23</td><td>L21 and driv$ adj2 track$</td><td>7</td><td>L23</td></tr>
<tr><td>L22</td><td>L21 and "drive-track"</td><td>0</td><td>L22</td></tr>
<tr><td>L21</td><td>(701/50 |701/81).ccls. and L20</td><td>199</td><td>L21</td></tr>
<tr><td colspan="4">DB=PGPB,USPT,USOC,EPAB,JPAB,DWPI,TDBD; THES=ASSIGNEE; PLUR=YES; OP=OR</td></tr>
<tr><td>L20</td><td>engine and ((construc$ adj vehicle$) or earth$)</td><td>43059</td><td>L20</td></tr>
<tr><td>L19</td><td>L2 and ((construc$ adj vehicle$) or earth$)</td><td>3</td><td>L19</td></tr>
<tr><td>L18</td><td>L2 and (construction$ adj vehicle$)</td><td>0</td><td>L18</td></tr>
<tr><td colspan="4">DB=USPT; THES=ASSIGNEE; PLUR=YES; OP=OR</td></tr>
<tr><td>L17</td><td>L16 and (load$ with fuel$ with suppl$)</td><td>0</td><td>L17</td></tr>
<tr><td>L16</td><td>L15 or L7</td><td>3</td><td>L16</td></tr>
<tr><td>L15</td><td>5121324.pn.</td><td>1</td><td>L15</td></tr>
<tr><td colspan="4">DB=PGPB,USPT,USOC,EPAB,JPAB,DWPI,TDBD; THES=ASSIGNEE; PLUR=YES; OP=OR</td></tr>
<tr><td>L14</td><td>L12 and (fuel$ with suppl$)</td><td>8</td><td>L14</td></tr>
</table>

L13	L12 and (fuel adj2 suppl$)	1	L13
L12	vehicle and (rack adj2 position)	1905	L12

DB=USPT; THES=ASSIGNEE; PLUR=YES; OP=OR

L11	L5 and (fuel$ with limit$)	1	L11
L10	L7 and (control$ with fuel$ with curve)	1	L10
L9	L7 and (modif$ with curve)	1	L9
L8	L7 and (modif$ with fuel$ with curve)	1	L8
L7	L5 or L6	2	L7
L6	5901684.pn.	1	L6
L5	5670830.pn.	1	L5

DB=PGPB,USPT,USOC,EPAB,JPAB,DWPI,TDBD; THES=ASSIGNEE; PLUR=YES; OP=OR

L4	L3 and (fuel$ with limit$)	14	L4
L3	L2 and vehicle	23	L3
L2	modif$ with fuel$ with curve	76	L2
L1	modif$ with fuel$ with curve with suppl$	1	L1

END OF SEARCH HISTORY

First Hit Previous Doc Next Doc Go to Doc#

Generate Collection Print

L44: Entry 3 of 45 File: PGPB Nov 30, 2006

PGPUB-DOCUMENT-NUMBER: 20060271267
PGPUB-FILING-TYPE:
DOCUMENT-IDENTIFIER: US 20060271267 A1

TITLE: Method of controlling an exhaust gas turbocharger

PUBLICATION-DATE: November 30, 2006

INVENTOR-INFORMATION:

NAME	CITY	STATE	COUNTRY
Augstein; Joachim	Steinheim/Murr		DE
Reissing; Marcus	Schorndorf		DE
Weik; Roland	Cleversulzbach		DE

APPL-NO: 11/474917 [PALM]
DATE FILED: June 21, 2006

RELATED-US-APPL-DATA:
parent US continuation-in-part PCT/EP04/14557 20041222 UNKNOWN
child US 11474917 A1 20060621

FOREIGN-APPL-PRIORITY-DATA:

COUNTRY	APPL-NO	DOC-ID	APPL-DATE
DE	103 61 114.2	2003DE-103 61 114.2	December 22, 2003

INT-CL-PUBLISHED:

TYPE	IPC	DATE	IPC-OLD
IPCP	G06F17/00	20060101	G06F017/00
IPCS	F02D23/00	20060101	F02D023/00

INT-CL-CURRENT:

TYPE	IPC	DATE
CIPS	F02 D 23/00	20070101
CIPP	G06 F 17/00	20070101

US-CL-PUBLISHED: 701/103; 060/602
US-CL-CURRENT: 701/103; 60/602

ABSTRACT:

In a method of controlling an exhaust gas turbocharger of an internal combustion engine charged by a compressor wherein as guide value for the control an operating point of the compressor is used, the operation of each cylinder bank of the internal combustion engine is controlled by dividing the total air mass flow by the

number of cylinder banks and the same amount of desired air mass flow is assigned to each cylinder bank and if the air mass flow to any of the cylinder banks is smaller than that to the other or others air from the other cylinder bank or banks is supplied to the one cylinder bank via a compensation arrangement so that the air mass flow to all cylinder banks is essentially the same.

[0001] This is a Continuation-In-Part Application of International Application PCT/EP2004/014557 filed Dec. 22, 2004 and claiming the priority of German Application 103 61 114.2 filed Dec. 22, 2003.

Previous Doc Next Doc Go to Doc#

L44: Entry 5 of 45 File: PGPB Mar 24, 2005

PGPUB-DOCUMENT-NUMBER: 20050065707
PGPUB-FILING-TYPE: new
DOCUMENT-IDENTIFIER: US 20050065707 A1

TITLE: Control device of internal combustion engine

PUBLICATION-DATE: March 24, 2005

INVENTOR-INFORMATION:

NAME	CITY	STATE	COUNTRY
Kaga, Tomoyuki	Lafayette	CA	US

APPL-NO: 10/938883 [PALM]
DATE FILED: September 13, 2004

FOREIGN-APPL-PRIORITY-DATA:

COUNTRY	APPL-NO	DOC-ID	APPL-DATE
JP	2003-327965(PAT.	2003JP-2003-327965(PAT.	September 19, 2003

INT-CL-PUBLISHED: [07] G06F 17/00, F01L 1/34

INT-CL-CURRENT:

TYPE	IPC	DATE
CIPP	F02 D 41/18	20060101

US-CL-PUBLISHED: 701/103; 123/090.15
US-CL-CURRENT: 701/103; 123/90.15

REPRESENTATIVE-FIGURES: 1

ABSTRACT:

A control device of an internal combustion engine provided with throttle air passage calculating means for calculating an amount of throttle air passage through a throttle valve, excess air calculating means for calculating an amount of excess air to a cylinder corresponding to drop in air pressure in intake pipe due to an intake valve for that cylinder opening, cylinder air charge estimating means for estimating a cylinder air charge amount for each cylinder based on the amount of throttle air passage detected by the throttle air passage detecting means and an amount of excess air calculated by the excess air calculating means, and engine control means for controlling the internal combustion engine based on the cylinder air charge amount for each cylinder estimated by the cylinder air charge estimating means.

L44: Entry 5 of 45 File: PGPB Mar 24, 2005

DOCUMENT-IDENTIFIER: US 20050065707 A1
TITLE: Control device of internal combustion engine

Current US Classification, US Primary Class/Subclass:
701/103

Detail Description Paragraph:
[0134] Therefore, in the present embodiment, first, the relationship between the operating angle VL and the correction gas amount .DELTA.Mi is found in advance by experiments and stored as a map in the ROM 34 of the ECU 31. Further, the operating angle VL at the time of certain detection conditions and the cylinder air charge amount Mci to the i-th cylinder at that time are estimated by the air estimation procedure of the first embodiment to the third embodiment. Further, the cylinder air charge amount Mci to the i-th cylinder estimated is reduced by the future average cylinder air charge amount Mc' calculated by the cylinder air charge model M10 at that cycle so as to calculate the correction gas amount .DELTA.Mi under the above certain detection conditions. For example, when the correction gas amount calculated when the operating angle is VL1 is .DELTA.Mi1, as shown in FIG. 13, this point is on the curve o. Therefore, the curve o is adopted as the curve of the correction gas amount for the i-th cylinder.

Refine Search

Your wildcard search against 10000 terms has yielded the results below.

Your result set for the last L# is incomplete.

The probable cause is use of unlimited truncation. Revise your search strategy to use limited truncation.

Search Results -

Terms	Documents
L43 and (reduc$ with (gas$ or energy$ or fuel$ or (power$ adj suppl$)))	45

Database:
US Pre-Grant Publication Full-Text Database
US Patents Full-Text Database
US OCR Full-Text Database
EPO Abstracts Database
JPO Abstracts Database
Derwent World Patents Index
IBM Technical Disclosure Bulletins

Search: 10/777140

Refine Search

Recall Text Clear Interrupt

Search History

DATE: Monday, September 10, 2007 **Purge Queries** Printable Copy Create Case

Set Name side by side	Query	Hit Count	Set Name result set
	DB=PGPB,USPT,USOC,EPAB,JPAB,DWPI,TDBD; THES=ASSIGNEE; PLUR=YES; OP=OR		
	L43 and (reduc$ with (gas$ or energy$ or fuel$ or (power$ adj suppl$)))	45	
	L41 and (((modif$ or edit$ or chang$ or correct$) near3 (gas$ or energy$ or fuel$)) with (curve$ or chart$ or graph$))	82	
	L41 and ((modif$ or edit$ or chang$ or correct$) near3 (gas$ or energy$ or fuel$ curve$ or chart$ or graph$))	903	
	123/379;701/101,103-104,112.ccls.	2165	
	L38 and ((modif$ or edit$ or chang$ or correct$) near2 ((gas$ or energy$ or fuel$ or (power$ adj suppl$)) adj3 (curve$ or chart$ or graph$)))	1	
	L38 and koga$	0	
	L36 or L37	13	

<table>
<tr><td>L37</td><td>@pd<=20030214 and ((modif$ or edit$) near3 ((gas$ or energy$ or fuel$ or (power$ adj suppl$)) adj3 (curve$ or chart$ or graph$))) and (vehicle$ or car$ or automobile$)</td><td>3</td><td>L37</td></tr>
<tr><td>L36</td><td>@ad<=20030214 and ((modif$ or edit$) near3 ((gas$ or energy$ or fuel$ or (power$ adj suppl$)) adj3 (curve$ or chart$ or graph$))) and (vehicle$ or car$ or automobile$)</td><td>12</td><td>L36</td></tr>
<tr><td>L35</td><td>@ad<=20030214 and ((modif$ or edit$) near3 ((gas$ or energy$ or fuel$ or (power$ adj suppl$)) adj (curve$ or chart$ or graph$))) and (vehicle$ or car$ or automobile$)</td><td>0</td><td>L35</td></tr>
<tr><td>L34</td><td>@ad<=20030214 and ((modif$ or edit$) near3 (fuel$ adj (curve$ or chart$ or graph$))) and (vehicle$ or car$ or automobile$)</td><td>0</td><td>L34</td></tr>
<tr><td>L33</td><td>@ad<=20030214 and (fuel$ with suppl$) and ((modif$ or edit$) near3 (fuel$ adj (curve$ or chart$ or graph$))) and (vehicle$ or car$ or automobile$)</td><td>0</td><td>L33</td></tr>
<tr><td>L32</td><td>@ad<=20030214 and (fuel$ with suppl$) and ((chang$ or modif$ or edit$ or correct$) with fuel$ with (curve or chart or graph)) and vehicle</td><td>921</td><td>L32</td></tr>
<tr><td>L31</td><td>@ad<=20030214 and (fuel$ with suppl$) and (fuel$ with (curve or chart or graph)) and vehicle</td><td>4080</td><td>L31</td></tr>
<tr><td colspan="4">DB=PGPB,USPT; THES=ASSIGNEE; PLUR=YES; OP=OR</td></tr>
<tr><td>L30</td><td>(701/50 |701/81).ccls.</td><td>1312</td><td>L30</td></tr>
<tr><td>L29</td><td>((sens$ same load$ same gear$) and (tranmission with rang$))</td><td>1</td><td>L29</td></tr>
<tr><td>L28</td><td>((sens$ same load$ same gear$) same (tranmission with rang$))</td><td>0</td><td>L28</td></tr>
<tr><td>L27</td><td>L21 and ((sens$ same load$ same gear$) same (tranmission with rang$))</td><td>0</td><td>L27</td></tr>
<tr><td colspan="4">DB=USPT; THES=ASSIGNEE; PLUR=YES; OP=OR</td></tr>
<tr><td>L26</td><td>L7 and (track$)</td><td>0</td><td>L26</td></tr>
<tr><td colspan="4">DB=PGPB,USPT; THES=ASSIGNEE; PLUR=YES; OP=OR</td></tr>
<tr><td>L25</td><td>L7 and (driv$ same track$)</td><td>0</td><td>L25</td></tr>
<tr><td colspan="4">DB=USPT; THES=ASSIGNEE; PLUR=YES; OP=OR</td></tr>
<tr><td>L24</td><td>L7 and (driv$ adj2 track$)</td><td>0</td><td>L24</td></tr>
<tr><td colspan="4">DB=PGPB,USPT; THES=ASSIGNEE; PLUR=YES; OP=OR</td></tr>
<tr><td>L23</td><td>L21 and driv$ adj2 track$</td><td>7</td><td>L23</td></tr>
<tr><td>L22</td><td>L21 and "drive-track"</td><td>0</td><td>L22</td></tr>
<tr><td>L21</td><td>(701/50 |701/81).ccls. and L20</td><td>199</td><td>L21</td></tr>
<tr><td colspan="4">DB=PGPB,USPT,USOC,EPAB,JPAB,DWPI,TDBD; THES=ASSIGNEE; PLUR=YES; OP=OR</td></tr>
<tr><td>L20</td><td>engine and ((construc$ adj vehicle$) or earth$)</td><td>43059</td><td>L20</td></tr>
<tr><td>L19</td><td>L2 and ((construc$ adj vehicle$) or earth$)</td><td>3</td><td>L19</td></tr>
<tr><td>L18</td><td>L2 and (construction$ adj vehicle$)</td><td>0</td><td>L18</td></tr>
<tr><td colspan="4">DB=USPT; THES=ASSIGNEE; PLUR=YES; OP=OR</td></tr>
<tr><td>L17</td><td>L16 and (load$ with fuel$ with suppl$)</td><td>0</td><td>L17</td></tr>
<tr><td>L16</td><td>L15 or L7</td><td>3</td><td>L16</td></tr>
<tr><td>L15</td><td>5121324.pn.</td><td>1</td><td>L15</td></tr>
<tr><td colspan="4">DB=PGPB,USPT,USOC,EPAB,JPAB,DWPI,TDBD; THES=ASSIGNEE; PLUR=YES; OP=OR</td></tr>
<tr><td>L14</td><td>L12 and (fuel$ with suppl$)</td><td>8</td><td>L14</td></tr>
</table>

L13	L12 and (fuel adj2 suppl$)	1	L13
L12	vehicle and (rack adj2 position)	1905	L12
	DB=USPT; THES=ASSIGNEE; PLUR=YES; OP=OR		
L11	L5 and (fuel$ with limit$)	1	L11
L10	L7 and (control$ with fuel$ with curve)	1	L10
L9	L7 and (modif$ with curve)	1	L9
L8	L7 and (modif$ with fuel$ with curve)	1	L8
L7	L5 or L6	2	L7
L6	5901684.pn.	1	L6
L5	5670830.pn.	1	L5
	DB=PGPB,USPT,USOC,EPAB,JPAB,DWPI,TDBD; THES=ASSIGNEE; PLUR=YES; OP=OR		
L4	L3 and (fuel$ with limit$)	14	L4
L3	L2 and vehicle	23	L3
L2	modif$ with fuel$ with curve	76	L2
L1	modif$ with fuel$ with curve with suppl$	1	L1

END OF SEARCH HISTORY

Hit List

First Hit Your wildcard search against 10000 terms has yielded the results below.

Your result set for the last L# is incomplete.

The probable cause is use of unlimited truncation. Revise your search strategy to use limited truncation.

Clear | Generate Collection | Print | Fwd Refs | Bkwd Refs

Generate OACS

Search Results - Record(s) 1 through 10 of 45 returned.

---

1. Document ID: US 20070151542 A1

L44: Entry 1 of 45 File: PGPB Jul 5, 2007

PGPUB-DOCUMENT-NUMBER: 20070151542
PGPUB-FILING-TYPE:
DOCUMENT-IDENTIFIER: US 20070151542 A1

TITLE: Control system for internal combustion engine

PUBLICATION-DATE: July 5, 2007

INVENTOR-INFORMATION:

NAME	CITY	STATE	COUNTRY
Yamaguchi; Satoshi	Wako-shi		JP
Hasegawa; Mamoru	Wako-shi		JP
Sakamoto; Hideki	Wako-shi		JP
Kitayama; Naoto	Wako-shi		JP

US-CL-CURRENT: 123/299; 123/436, 123/478, 701/104, 701/105

Full | Title | Citation | Front | Review | Classification | Date | Reference | Sequences | Attachments | Claims | KWIC | Draw De

---

2. Document ID: US 20070084435 A1

L44: Entry 2 of 45 File: PGPB Apr 19, 2007

PGPUB-DOCUMENT-NUMBER: 20070084435
PGPUB-FILING-TYPE:
DOCUMENT-IDENTIFIER: US 20070084435 A1

TITLE: Control system for internal combustion engine

PUBLICATION-DATE: April 19, 2007

INVENTOR-INFORMATION:

NAME	CITY	STATE	COUNTRY
Yamaguchi; Satoshi	Wako-shi		JP

Hasegawa; Mamoru	Wako-shi	JP
Kitayama; Naoto	Wako-shi	JP
Sakamoto; Hideki	Wako-shi	JP
Itoh; Yoshihiro	Wako-shi	JP

US-CL-CURRENT: 123/299; 123/435, 123/478, 701/104, 701/105

Full | Title | Citation | Front | Review | Classification | Date | Reference | Sequences | Attachments | Claims | KWIC | Draw De

---

3. Document ID: US 20060271267 A1

L44: Entry 3 of 45 File: PGPB Nov 30, 2006

PGPUB-DOCUMENT-NUMBER: 20060271267
PGPUB-FILING-TYPE:
DOCUMENT-IDENTIFIER: US 20060271267 A1

TITLE: Method of controlling an exhaust gas turbocharger

PUBLICATION-DATE: November 30, 2006

INVENTOR-INFORMATION:

NAME	CITY	STATE	COUNTRY
Augstein; Joachim	Steinheim/Murr		DE
Reissing; Marcus	Schorndorf		DE
Weik; Roland	Cleversülzbach		DE

US-CL-CURRENT: 701/103; 60/602

Full | Title | Citation | Front | Review | Classification | Date | Reference | Sequences | Attachments | Claims | KWIC | Draw De

---

4. Document ID: US 20060142923 A1

L44: Entry 4 of 45 File: PGPB Jun 29, 2006

PGPUB-DOCUMENT-NUMBER: 20060142923
PGPUB-FILING-TYPE:
DOCUMENT-IDENTIFIER: US 20060142923 A1

TITLE: Fuel injection control apparatus for direct injection type internal combustion engine

PUBLICATION-DATE: June 29, 2006

INVENTOR-INFORMATION:

NAME	CITY	STATE	COUNTRY
Honda; Koji	Toyota-shi		JP
Teraoka; Masahiko	Toyota-shi		JP
Idogawa; Masanao	Toyota-shi		JP
Hirowatari; Seiji	Toyota-shi		JP

US-CL-CURRENT: 701/104

Full	Title	Citation	Front	Review	Classification	Date	Reference	Sequences	Attachments	Claims	KWIC	Draw. D

---

5. Document ID: US 20050065707 A1

L44: Entry 5 of 45 File: PGPB Mar 24, 2005

PGPUB-DOCUMENT-NUMBER: 20050065707
PGPUB-FILING-TYPE: new
DOCUMENT-IDENTIFIER: US 20050065707 A1

TITLE: Control device of internal combustion engine

PUBLICATION-DATE: March 24, 2005

INVENTOR-INFORMATION:

NAME	CITY	STATE	COUNTRY
Kaga, Tomoyuki	Lafayette	CA	US

US-CL-CURRENT: 701/103; 123/90.15

Full	Title	Citation	Front	Review	Classification	Date	Reference	Sequences	Attachments	Claims	KWIC	Draw. D

---

6. Document ID: US 20040133335 A1

L44: Entry 6 of 45 File: PGPB Jul 8, 2004

PGPUB-DOCUMENT-NUMBER: 20040133335
PGPUB-FILING-TYPE: new
DOCUMENT-IDENTIFIER: US 20040133335 A1

TITLE: Fuel injection control device

PUBLICATION-DATE: July 8, 2004

INVENTOR-INFORMATION:

NAME	CITY	STATE	COUNTRY
Nakano, Futoshi	Fujisawa-shi		JP
Hirata, Akira	Fujisawa-shi		JP
Yomogida, Koichiro	Fujisawa-shi		JP

US-CL-CURRENT: 701/103

Full	Title	Citation	Front	Review	Classification	Date	Reference	Sequences	Attachments	Claims	KWIC	Draw. D

---

7. Document ID: US 20020157652 A1

L44: Entry 7 of 45 File: PGPB Oct 31, 2002

PGPUB-DOCUMENT-NUMBER: 20020157652
PGPUB-FILING-TYPE: new
DOCUMENT-IDENTIFIER: US 20020157652 A1

TITLE: Fuel injection amount control apparatus and method for internal combustion engine

PUBLICATION-DATE: October 31, 2002

INVENTOR-INFORMATION:

NAME	CITY	STATE	COUNTRY
Hoshi, Koichi	Susono-shi		JP

US-CL-CURRENT: 123/491; 701/104

Full | Title | Citation | Front | Review | Classification | Date | Reference | Sequences | Attachments | Claims | KWIC | Draw De

---

8. Document ID: US 20020014363 A1

L44: Entry 8 of 45 File: PGPB Feb 7, 2002

PGPUB-DOCUMENT-NUMBER: 20020014363
PGPUB-FILING-TYPE: new
DOCUMENT-IDENTIFIER: US 20020014363 A1

TITLE: Vehicle drive power control apparatus, and control method

PUBLICATION-DATE: February 7, 2002

INVENTOR-INFORMATION:

NAME	CITY	STATE	COUNTRY
Kubota, Hirofumi	Mishima-shi		JP
Mashiki, Zenichiro	Nisshin-shi		JP
Takagi, Isao	Okazaki-shi		JP
Tanaka, Hiroya	Nishikamo-gun		JP
Mitani, Shinichi	Susono-shi		JP

US-CL-CURRENT: 180/197; 701/103

Full | Title | Citation | Front | Review | Classification | Date | Reference | Sequences | Attachments | Claims | KWIC | Draw De

---

9. Document ID: US 20020013653 A1

L44: Entry 9 of 45 File: PGPB Jan 31, 2002

PGPUB-DOCUMENT-NUMBER: 20020013653
PGPUB-FILING-TYPE: new
DOCUMENT-IDENTIFIER: US 20020013653 A1

TITLE: Control apparatus for drive system

PUBLICATION-DATE: January 31, 2002

INVENTOR-INFORMATION:

NAME	CITY	STATE	COUNTRY
Ohyama, Yoshishige	Hitachinaka-shi	MI	JP
Fujieda, Mamoru	Nishiibaraki-gun		JP
Nogi, Toshiharu	Novi		US
Shiraishi, Takuya	Hitachinaka-shi		JP
Ohsuga, Minoru	Hitachinaka-shi		JP

US-CL-CURRENT: 701/103; 701/104

Full | Title | Citation | Front | Review | Classification | Date | Reference | Sequences | Attachments | Claims | KWIC | Draw. D

---

10. Document ID: US 20020010539 A1

L44: Entry 10 of 45 File: PGPB Jan 24, 2002

PGPUB-DOCUMENT-NUMBER: 20020010539
PGPUB-FILING-TYPE: new
DOCUMENT-IDENTIFIER: US 20020010539 A1

TITLE: Fuel injection control apparatus

PUBLICATION-DATE: January 24, 2002

INVENTOR-INFORMATION:

NAME	CITY	STATE	COUNTRY
Machida, Kenichi	Saitama		JP
Hirakata, Yoshiaki	Saitama		JP
Yuhara, Tomomi	Saitama		JP
Abe, Masahiko	Saitama		JP

US-CL-CURRENT: 701/104; 123/478, 477/111

Full | Title | Citation | Front | Review | Classification | Date | Reference | Sequences | Attachments | Claims | KWIC | Draw. D

Clear | Generate Collection | Print | Fwd Refs | Bkwd Refs | Generate OACS

Terms	Documents
L43 and (reduc$ with (gas$ or energy$ or fuel$ or (power$ adj suppl$)))	45

Hit List

First Hit Your wildcard search against 10000 terms has yielded the results below.

Your result set for the last L# is incomplete.

The probable cause is use of unlimited truncation. Revise your search strategy to use limited truncation.

Clear | Generate Collection | Print | Fwd Refs | Bkwd Refs

Generate OACS

Search Results - Record(s) 11 through 20 of 45 returned.

---

11. Document ID: US 20010008990 A1

L44: Entry 11 of 45 File: PGPB Jul 19, 2001

PGPUB-DOCUMENT-NUMBER: 20010008990
PGPUB-FILING-TYPE: new-utility
DOCUMENT-IDENTIFIER: US 20010008990 A1

TITLE: Air-fuel ratio controller for engine

PUBLICATION-DATE: July 19, 2001

INVENTOR-INFORMATION:

NAME	CITY	STATE	COUNTRY
Ishii, Toshio	Mito-shi		JP
Takaku, Yutaka	Mito-shi		JP

US-CL-CURRENT: 701/109; 123/695, 123/696, 60/276, 701/103

Full | Title | Citation | Front | Review | Classification | Date | Reference | Sequences | Attachments | Claims | KWIC | Draw D

---

12. Document ID: US 7159547 B2

L44: Entry 12 of 45 File: USPT Jan 9, 2007

US-PAT-NO: 7159547
DOCUMENT-IDENTIFIER: US 7159547 B2

TITLE: Control apparatus for multi-cylinder internal combustion engine and control method

PRIOR-PUBLICATION:

DOC-ID	DATE
US 20060207582 A1	September 21, 2006

Full | Title | Citation | Front | Review | Classification | Date | Reference | | | Claims | KWIC | Draw D

13. Document ID: US 7137379 B2

L44: Entry 13 of 45 File: USPT Nov 21, 2006

US-PAT-NO: 7137379
DOCUMENT-IDENTIFIER: US 7137379 B2

TITLE: Method for rich pulse control of diesel engines

PRIOR-PUBLICATION:

DOC-ID	DATE
US 20060037307 A1	February 23, 2006

Full | Title | Citation | Front | Review | Classification | Date | Reference | | | Claims | KWIC | Draw De

14. Document ID: US 7073493 B2

L44: Entry 14 of 45 File: USPT Jul 11, 2006

US-PAT-NO: 7073493
DOCUMENT-IDENTIFIER: US 7073493 B2

TITLE: Control apparatus for multi-cylinder internal combustion engine and control method

PRIOR-PUBLICATION:

DOC-ID	DATE
US 20020104520 A1	August 8, 2002

Full | Title | Citation | Front | Review | Classification | Date | Reference | | | Claims | KWIC | Draw De

15. Document ID: US 7069910 B2

L44: Entry 15 of 45 File: USPT Jul 4, 2006

US-PAT-NO: 7069910
DOCUMENT-IDENTIFIER: US 7069910 B2

TITLE: Overall scheduling of a lean burn engine system

PRIOR-PUBLICATION:

DOC-ID	DATE
US 20050076887 A1	April 14, 2005

Full | Title | Citation | Front | Review | Classification | Date | Reference | | | Claims | KWIC | Draw De

16. Document ID: US 7043352 B2

L44: Entry 16 of 45 File: USPT May 9, 2006

US-PAT-NO: 7043352
DOCUMENT-IDENTIFIER: US 7043352 B2

TITLE: Internal combustion engine control device

PRIOR-PUBLICATION:

DOC-ID	DATE
US 20050188948 A1	September 1, 2005

Full | Title | Citation | Front | Review | Classification | Date | Reference | | | Claims | KWIC | Draw De

---

17. Document ID: US 7003390 B2

L44: Entry 17 of 45 File: USPT Feb 21, 2006

US-PAT-NO: 7003390
DOCUMENT-IDENTIFIER: US 7003390 B2

TITLE: Control device of internal combustion engine

PRIOR-PUBLICATION:

DOC-ID	DATE
US 20050065707 A1	March 24, 2005

Full | Title | Citation | Front | Review | Classification | Date | Reference | | | Claims | KWIC | Draw De

---

18. Document ID: US 6988359 B2

L44: Entry 18 of 45 File: USPT Jan 24, 2006

US-PAT-NO: 6988359
DOCUMENT-IDENTIFIER: US 6988359 B2

TITLE: Exhaust gas control apparatus and exhaust gas purification method for internal combustion engine

PRIOR-PUBLICATION:

DOC-ID	DATE
US 20040045282 A1	March 11, 2004

Full | Title | Citation | Front | Review | Classification | Date | Reference | | | Claims | KWIC | Draw De

---

19. Document ID: US 6976382 B2

L44: Entry 19 of 45 File: USPT Dec 20, 2005

US-PAT-NO: 6976382
DOCUMENT-IDENTIFIER: US 6976382 B2

TITLE: Abnormality diagnosing apparatus of exhaust gas sensor

Full | Title | Citation | Front | Review | Classification | Date | Reference | | | Claims | KWIC | Draw. D

---

20. Document ID: US 6959242 B2

L44: Entry 20 of 45 File: USPT Oct 25, 2005

US-PAT-NO: 6959242
DOCUMENT-IDENTIFIER: US 6959242 B2

TITLE: Engine fuel injection control device

Full | Title | Citation | Front | Review | Classification | Date | Reference | | | Claims | KWIC | Draw. D

Clear | Generate Collection | Print | Fwd Refs | Bkwd Refs | Generate OACS

Terms	Documents
L43 and (reduc$ with (gas$ or energy$ or fuel$ or (power$ adj suppl$)))	45

Display Format: - | Change Format

Previous Page   Next Page   Go to Doc#

Hit List

First Hit Your wildcard search against 10000 terms has yielded the results below.

Your result set for the last L# is incomplete.

The probable cause is use of unlimited truncation. Revise your search strategy to use limited truncation.

Clear | Generate Collection | Print | Fwd Refs | Bkwd Refs | Generate OACS

Search Results - Record(s) 31 through 40 of 45 returned.

---

31. Document ID: US 6053036 A

L44: Entry 31 of 45 File: USPT Apr 25, 2000

US-PAT-NO: 6053036
DOCUMENT-IDENTIFIER: US 6053036 A
**** See image for Certificate of Correction ****

TITLE: Fuel supply amount control system for internal combustion engines

Full | Title | Citation | Front | Review | Classification | Date | Reference | | | Claims | KMC | Draw. D

---

32. Document ID: US 5988144 A

L44: Entry 32 of 45 File: USPT Nov 23, 1999

US-PAT-NO: 5988144
DOCUMENT-IDENTIFIER: US 5988144 A

TITLE: Engine air-fuel ratio controller

Full | Title | Citation | Front | Review | Classification | Date | Reference | | | Claims | KMC | Draw. D

---

33. Document ID: US 5672817 A

L44: Entry 33 of 45 File: USPT Sep 30, 1997

US-PAT-NO: 5672817
DOCUMENT-IDENTIFIER: US 5672817 A

TITLE: Self-diagnostic apparatus of air-fuel ratio control system of internal combustion engine

Full | Title | Citation | Front | Review | Classification | Date | Reference | | | Claims | KMC | Draw. D

---

34. Document ID: US 5319558 A

L44: Entry 34 of 45 File: USPT Jun 7, 1994

US-PAT-NO: 5319558
DOCUMENT-IDENTIFIER: US 5319558 A

TITLE: Engine control method and apparatus

Full | Title | Citation | Front | Review | Classification | Date | Reference | | | Claims | KWIC | Draw De

---

35. Document ID: US 5227975 A

L44: Entry 35 of 45 File: USPT Jul 13, 1993

US-PAT-NO: 5227975
DOCUMENT-IDENTIFIER: US 5227975 A

TITLE: Air/fuel ratio feedback control system for internal combustion engine

Full | Title | Citation | Front | Review | Classification | Date | Reference | | | Claims | KWIC | Draw De

---

36. Document ID: US 5126943 A

L44: Entry 36 of 45 File: USPT Jun 30, 1992

US-PAT-NO: 5126943
DOCUMENT-IDENTIFIER: US 5126943 A

TITLE: Learning-correcting method and apparatus and self-diagnosis method and apparatus in fuel supply control system of internal combustion engine

Full | Title | Citation | Front | Review | Classification | Date | Reference | | | Claims | KWIC | Draw De

---

37. Document ID: US 5050084 A

L44: Entry 37 of 45 File: USPT Sep 17, 1991

US-PAT-NO: 5050084
DOCUMENT-IDENTIFIER: US 5050084 A

TITLE: Method and apparatus for controlling supply of fuel into internal combustion engine

Full | Title | Citation | Front | Review | Classification | Date | Reference | | | Claims | KWIC | Draw De

---

38. Document ID: US 5050083 A

L44: Entry 38 of 45 File: USPT Sep 17, 1991

US-PAT-NO: 5050083

DOCUMENT-IDENTIFIER: US 5050083 A

TITLE: System and method for controlling air/fuel mixture ratio for internal combustion engine

Full | Title | Citation | Front | Review | Classification | Date | Reference | | | Claims | KWIC | Draw. D

---

39. **Document ID: US 4922877 A**

L44: Entry 39 of 45 File: USPT May 8, 1990

US-PAT-NO: 4922877
DOCUMENT-IDENTIFIER: US 4922877 A

TITLE: System and method for controlling fuel injection quantity for internal combustion engine

Full | Title | Citation | Front | Review | Classification | Date | Reference | | | Claims | KWIC | Draw. D

---

40. **Document ID: US 4920494 A**

L44: Entry 40 of 45 File: USPT Apr 24, 1990

US-PAT-NO: 4920494
DOCUMENT-IDENTIFIER: US 4920494 A

TITLE: Fuel monitoring arrangement for automotive internal combustion engine control system

Full | Title | Citation | Front | Review | Classification | Date | Reference | | | Claims | KWIC | Draw. D

Clear | Generate Collection | Print | Fwd Refs | Bkwd Refs | Generate OACS

Terms	Documents
L43 and (reduc$ with (gas$ or energy$ or fuel$ or (power$ adj suppl$)))	45

Display Format: - Change Format

Previous Page Next Page Go to Doc#

Hit List

First Hit Your wildcard search against 10000 terms has yielded the results below.

Your result set for the last L# is incomplete.

The probable cause is use of unlimited truncation. Revise your search strategy to use limited truncation.

Clear | Generate Collection | Print | Fwd Refs | Bkwd Refs

Generate OACS

Search Results - Record(s) 41 through 45 of 45 returned.

41. Document ID: US 4725954 A

L44: Entry 41 of 45 File: USPT Feb 16, 1988

US-PAT-NO: 4725954
DOCUMENT-IDENTIFIER: US 4725954 A

TITLE: Apparatus and method for controlling fuel supply to internal combustion engine

Full | Title | Citation | Front | Review | Classification | Date | Reference | | | Claims | KWIC | Draw. D

42. Document ID: US 4481928 A

L44: Entry 42 of 45 File: USPT Nov 13, 1984

US-PAT-NO: 4481928
DOCUMENT-IDENTIFIER: US 4481928 A

TITLE: L-Jetronic fuel injected engine control device and method smoothing air flow meter overshoot

Full | Title | Citation | Front | Review | Classification | Date | Reference | | | Claims | KWIC | Draw. D

43. Document ID: US 4349877 A

L44: Entry 43 of 45 File: USPT Sep 14, 1982

US-PAT-NO: 4349877
DOCUMENT-IDENTIFIER: US 4349877 A

TITLE: Electronically controlled carburetor

Full | Title | Citation | Front | Review | Classification | Date | Reference | | | Claims | KWIC | Draw. D

44. Document ID: US 4063538 A

L44: Entry 44 of 45 File: USPT Dec 20, 1977

US-PAT-NO: 4063538
DOCUMENT-IDENTIFIER: US 4063538 A

TITLE: Ignition timing control method and apparatus

Full | Title | Citation | Front | Review | Classification | Date | Reference | | | Claims | KWIC | Draw De

---

45. Document ID: US 3969614 A

L44: Entry 45 of 45 File: USPT Jul 13, 1976

US-PAT-NO: 3969614
DOCUMENT-IDENTIFIER: US 3969614 A

TITLE: Method and apparatus for engine control

Full | Title | Citation | Front | Review | Classification | Date | Reference | | | Claims | KWIC | Draw De

---

Clear | Generate Collection | Print | Fwd Refs | Bkwd Refs | Generate OACS

Terms	Documents
L43 and (reduc$ with (gas$ or energy$ or fuel$ or (power$ adj suppl$)))	45

Display Format: - | Change Format

Previous Page | Next Page | Go to Doc#

L44: Entry 12 of 45 File: USPT Jan 9, 2007

DOCUMENT-IDENTIFIER: US 7159547 B2
TITLE: Control apparatus for multi-cylinder internal combustion engine and control method

PRIOR-PUBLICATION:

DOC-ID	DATE
US 20060207582 A1	September 21, 2006

Abstract Text (1):
A control apparatus calculates a exhaust gas air-fuel ratio of a plurality of cylinders, in which the operation angle of an intake valve is set to a predetermined operation angle, e.g., a maximum operation angle, based on a value output from an air-fuel ratio sensor so as to minimize a variation in an fuel injection quantity between the plurality of cylinders by that exhaust gas air-fuel ratio. That is, the exhaust gas air-fuel ratio of the plurality of cylinders, in which the valve opening characteristics of the intake valve and an exhaust valve are set such that the intake air amount to be introduced into the plurality of cylinders is limited by the opening amount of a throttle valve, for example, and not limited by the valve opening characteristics of the intake valve or the exhaust valve is calculated, and the variation in the fuel injection quantity among the plurality of cylinders is then reduced by that exhaust gas air-fuel ratio. Then, the variation in valve opening characteristics among the cylinders is reduced.

Brief Summary Text (5):
Conventionally, a control apparatus for a multi-cylinder internal combustion engine, which reduces variation in the air-fuel ratio between cylinders is known. An example of this type of control apparatus is disclosed in Japanese Patent Application Laid-Open Publication No. 6-213044. The control apparatus disclosed in this publication calculates the air-fuel ratio of each of a plurality of cylinders based on a value output from an air-fuel sensor. Any variation in the air-fuel ratios between the cylinders is then minimized by controlling the valve lift amount of each of the cylinders.

Brief Summary Text (12):
According to one aspect of the invention, a control apparatus for a multi-cylinder internal combustion engine including a plurality of cylinders is provided with a controller that calculates an exhaust gas air-fuel ratio of a cylinder when valve opening characteristics of an intake valve and an exhaust valve of each of the cylinders of the internal combustion engine are set such that an amount of an intake air introduced into the cylinder is not limited by the valve opening characteristics; and reduces a variation in a fuel injection quantity among the cylinders on the basis of the calculated exhaust gas air-fuel ratio of each of the cylinders.

Brief Summary Text (14):
In the control apparatus, when the valve opening characteristics of the intake valve and the exhaust valve of the cylinder are set so as not to limit the quantity of air introduced into the cylinder, the exhaust gas air-fuel ratio of the cylinder is calculated. Preferably, when the valve opening characteristics of the intake

valve and the exhaust valve of the cylinder are set such that the quantity of air introduced into the cylinder is limited by the throttle valve opening amount and not limited by the valve opening characteristics, the exhaust gas air-fuel ratio of the cylinder is calculated. In order to calculate an exhaust gas air-fuel ratio of each of the cylinders, the valve opening characteristics of the intake valve and the exhaust valve of the cylinder are set such that quantity of the intake air introduced into the cylinder is limited by the throttle valve opening amount and not limited by the valve opening characteristics of the intake and exhaust valves of the cylinder. In other words, the throttle valve opening amount of one cylinder upon calculation of the exhaust gas air-fuel ratio of the cylinder is made substantially equivalent to that of an other cylinder upon calculation of the exhaust gas air-fuel ratio of the other cylinder so as to make the quantity of the intake air introduced into the one cylinder upon calculation of the exhaust gas air-fuel ratio of the one cylinder equivalent to that of the other cylinder. Further in the invention, the amount of the intake air introduced into one cylinder upon calculation of the exhaust gas air-fuel ratio of the cylinder is made equivalent to that of the exhaust gas air fuel ratio of the other cylinder so as to obtain the exhaust gas air-fuel ratio of the cylinder. As a result, a variation in the fuel injection amount among the cylinders can be reduced on the basis of the exhaust gas air-fuel ratio. Accordingly, each amount of the intake air introduced into each of the cylinders is made equivalent, and then the respective fuel injection quantity is corrected so as to make each exhaust gas air-fuel ratio of the cylinders equivalent. Unlike the control apparatus disclosed in Japanese Patent Application Laid-Open Publication No. 6-213044, the variation in the air-fuel ratio among the cylinders is reduced while controlling a variation in torque among the cylinders when there is variation in the fuel injection quantity among the cylinders, thus preventing pulsation. That is, the control apparatus of this aspect of the invention reduces a variation in the air-fuel ratio among the cylinders as well as a variation in torque among the cylinders.

Brief Summary Text (15):
According to another aspect of the invention, a control apparatus for a multi-cylinder internal combustion engine including a plurality of cylinders is provided with a controller that calculates an exhaust gas air-fuel ratio of each of the cylinders when an operation angle of an intake valve of each of the cylinders of the internal combustion engine is set to a predetermined angle, and reduces a variation in a fuel injection quantity among the cylinders on the basis of the calculated exhaust gas air-fuel ratio of each of the cylinders.

Brief Summary Text (20):
In the control apparatus, the amount of the intake air introduced into one cylinder upon calculation of the exhaust gas air-fuel ratio of that cylinder is made equivalent to that of the other cylinder such that a variation in the fuel injection quantity can be minimized on the basis of the calculated exhaust gas air-fuel ratio. Accordingly, the amount of the intake air introduced to each of the cylinders is made equivalent and the fuel injection quantity is corrected so as to make the exhaust gas air-fuel ratio of each of the cylinders equivalent. Unlike the control apparatus disclosed in Japanese Patent Application Laid-Open Publication No. 6-213044, the variation in the air-fuel ratio among the cylinders can be reduced while controlling a variation in the torque among the cylinders in the presence of the variation in the fuel injection quantity among the cylinders, thus preventing pulsation. Accordingly, the variation both in the air-fuel ratio and in the torque among the cylinders can be reduced.

Brief Summary Text (21):
According to another aspect of the invention, a control apparatus for a multi-cylinder internal combustion engine is provided with a controller that calculates an exhaust gas air-fuel ratio of each of the cylinders when a valve overlap amount of an intake valve and an exhaust valve of each of the cylinders of the internal combustion engine is set to a predetermined amount, and reduces a variation in a

fuel injection quantity among the plurality of cylinders on the basis of the calculated exhaust gas air-fuel ratio of each of the cylinders.

Brief Summary Text (25):
In the control apparatus according to another aspect of the invention, an exhaust gas air-fuel ratio of each of the cylinders is calculated in which a valve overlap amount of the intake valve and the exhaust valve is set to a predetermined amount. More specifically, the control apparatus calculates the exhaust gas air-fuel ratio of each of the cylinders in which the overlap amount of the intake valve and the exhaust valve is set so as not to limit the quantity of air introduced into the cylinders. Preferably, the control apparatus calculates the exhaust gas air-fuel ratio of each of the cylinders in which the valve overlap amount of the intake valve and the exhaust valve is set such that the intake air amount introduced into the cylinders is limited by the throttle valve opening amount, and is not limited by the valve overlap amount of the intake valve and the exhaust valve. Most preferably, the control apparatus calculates the exhaust gas air-fuel ratio of each of the cylinders in which the valve overlap amount of the intake valve and the exhaust valve is set to a minimum valve overlap amount. That is, the control apparatus calculates the exhaust gas air-fuel ratio of a certain cylinder, when the valve overlap amount of the intake valve and the exhaust valve is set to the minimum amount so that the intake air amount introduced into that cylinder is limited by the throttle valve opening amount, and is not limited by the valve overlap amount. In other words, the intake air amount into a cylinder upon calculation of the exhaust gas air-fuel ratio of the cylinder is made equivalent to that of the other cylinder by making the throttle valve opening amount upon calculation of the exhaust gas air-fuel ratio of a cylinder substantially equivalent to that of the other cylinder. In the control apparatus, the variation in the fuel injection quantity among cylinders can be reduced by making the intake air amount into a cylinder upon calculation of the exhaust gas air-fuel ratio of the cylinder equivalent to that of the other cylinder. In other words, the intake air amount of all cylinders is made equivalent and the fuel injection quantity is corrected so as to make all the exhaust gas air-fuel ratios of the cylinders equivalent. Unlike Japanese Patent Application Laid-Open Publication No. 6-213044, the variation in the air-fuel ratio among the cylinders can be reduced while reducing the variation in the torque among the cylinders in the presence of the variation in the fuel injection quantity among the cylinders, thus preventing pulsation. More specifically, the control apparatus is capable of minimizing the variation both in the air-fuel ratio and the torque among the cylinders.

Brief Summary Text (26):
In the control apparatus according to another aspect of the invention, the controller calculates an exhaust gas air-fuel ratio of each of the cylinders when the valve opening characteristics of the intake valve and the exhaust valve are set such that the amount of the intake air introduced into the cylinder is limited by the valve opening characteristics after reducing the variation in the fuel injection quantity among the plurality of cylinders; and reduces a variation in the valve opening characteristics of the intake valve and the exhaust valve among the plurality of cylinders on the basis of the calculated exhaust gas air-fuel ratio of the cylinders.

Brief Summary Text (28):
The control apparatus according to another aspect of the invention calculates, after reducing the variation in the fuel injection quantity among the cylinders, the exhaust gas air-fuel ratio of a cylinder in which the valve opening characteristics of the intake valve and the exhaust valve are set so as to limit the intake air amount introduced into the cylinder, and then reduces the variation in the valve opening characteristics of the intake valve and the exhaust valve among the cylinders based on the set exhaust gas air-fuel ratio. More preferably, the control apparatus calculates, after reducing the variation in the fuel injection quantity among the cylinders, the exhaust gas air-fuel ratio of the

cylinder in which the valve opening characteristics of the intake valve and the exhaust valve are set such that the intake air amount introduced into the cylinder is limited by the valve opening characteristics of the intake valve or exhaust valve, and is not limited by the throttle valve opening amount, and then reduces the variation in the valve opening characteristics of the intake valve and the exhaust valve among the cylinders based on the calculated exhaust gas air-fuel ratio. That is, after reducing the variation in the fuel injection quantity among the cylinders, the control apparatus changes the valve opening characteristics of the intake valve and the exhaust valve of each cylinder so that the exhaust gas air-fuel ratio of one cylinder is made equivalent to that of another cylinder. The control apparatus is capable of reducing the variation in the valve opening characteristics of the intake valve and the exhaust valve among the cylinders without generating variation in the torque among the cylinders irrespective of the variation in the fuel injection quantity among the cylinders.

Brief Summary Text (29):
In the control apparatus, the controller calculates the exhaust gas air-fuel ratio of each of the cylinders when the operation angle of the intake valve is set to an operation angle that is smaller than the predetermined operation angle after reducing the variation in the fuel injection quantity among the cylinders, and reduces a variation in the amount of the intake air among the cylinders on the basis of the calculated exhaust gas air-fuel ratio of each of the cylinders.

Brief Summary Text (30):
The control apparatus of the invention calculates, after reducing the variation in the fuel injection quantity among the cylinders, the exhaust gas air-fuel ratio of each of the cylinders in which the operation angle of the intake valve is set to an operation angle smaller than the predetermined operation angle, and then reduces the variation in the intake air amount among the cylinders on the basis of the calculated exhaust gas air-fuel ratio. That is, after reducing the variation in the fuel injection quantity among the cylinders, the operation angle of the intake valve of each cylinder is changed such that the exhaust gas air-fuel ratio of one cylinder is made equivalent to that of another cylinder. The control apparatus is capable of reducing the variation in the intake air amount among the cylinders without generating variation in torque among the cylinders irrespective of the variation in the fuel injection quantity among the cylinders.

Brief Summary Text (31):
In the control apparatus, the controller calculates the exhaust gas air-fuel ratio of each of the cylinders when the operation angle of the intake valve is set to an operation angle that is smaller than the predetermined operation angle after reducing the variation in the fuel injection quantity among the cylinders, and reduces a variation in the operation angle of the intake valve among the cylinders on the basis of the calculated exhaust gas air-fuel ratio of each of the cylinders.

Brief Summary Text (32):
The control apparatus of the invention calculates, after reducing the variation in the fuel injection quantity among the cylinders, the exhaust gas air-fuel ratio of the cylinder in which the operation angle of the intake valve is set to an operation angle smaller than the predetermined operation angle, and then reduces the variation in the operation angle of the intake valve among the cylinders on the basis of the calculated exhaust gas air-fuel ratio. That is, after reducing the variation in the fuel injection quantity among the cylinders, the operation angle of the intake valve of each cylinder is changed such that the exhaust gas air-fuel ratio of one cylinder is made equivalent to that of another cylinder. The control apparatus is capable of reducing the variation in the intake air amount among the cylinders without generating a variation in torque among the cylinders irrespective of the variation in the fuel injection quantity among the cylinders.

Brief Summary Text (36):
In the control apparatus, the controller reduces a variation in a fuel injection quantity among the cylinders on the basis of the valve overlap amount of the intake valve and the exhaust valve of each of the cylinders.

Brief Summary Text (37):
The control apparatus of this aspect of the invention reduces the variation among the cylinders on the basis of a valve overlap amount of the intake valve and the exhaust valve. More specifically, the control apparatus reduces the variation in the fuel injection quantity among the cylinders on the basis of the valve overlap amount of the intake valve and the exhaust valve. The control apparatus of the invention is capable of reducing the variation in the air-fuel ratio among the cylinders more effectively when the valve overlap amount can be changed than the control apparatus for a multi-cylinder internal combustion engine disclosed in Japanese Patent Application Laid-Open Publication No. 6-213044, in which the variation among the cylinders cannot be reduced on the basis of the valve overlap amount of the intake valve and the exhaust valve. In other words, the control apparatus is capable of appropriately controlling the variation in the air-fuel ratio among the cylinders.

Brief Summary Text (39):
In the control apparatus, the controller reduces a variation in an air-fuel ratio among the cylinders on the basis of the operation angle of the intake valve of each of the cylinders.

Brief Summary Text (40):
The control apparatus of this aspect of the invention reduces a variation among the cylinders on the basis of an operation angle of the intake valve. More specifically, the control apparatus reduces the variation in the air-fuel ratio among the cylinders on the basis of the operation angle of the intake valve. Unlike the control apparatus for a multi-cylinder internal combustion engine disclosed in Japanese Patent Application Laid-Open Publication No. 6-213044, in which a variation between cylinders cannot be reduced on the basis of the operation angle of the intake valve, the control apparatus of the invention is capable of reducing the variation in the air-fuel ratio among the cylinders appropriately even when the operation angle of the intake valve is changed. The variation in the air-fuel ratio among the cylinders, thus, can be appropriately controlled.

Brief Summary Text (41):
In the control apparatus, the controller reduces a variation in the air-fuel ratio among the cylinders by correcting a fuel injection quantity on the basis of the operation angle of the intake valve.

Brief Summary Text (45):
The control apparatus as described above reduces the variation in the air-fuel ratio among the cylinders by correcting the fuel injection quantity on the basis of the operation angle of the intake valve. For example, when the air-fuel ratio of one cylinder varies on the rich side, the fuel injection quantity supplied to the cylinder is decreased so as to reduce the variation in the air-fuel ratio among the cylinders. Also, the smaller the operation angle of the intake valve becomes, the greater the variation in the air-fuel ratio becomes among the cylinders when the actual operation angle deviates from the target operation angle. In view of this, the variation in the air-fuel ratio among the cylinders can be reduced by executing correction, for example, increasing the fuel injection quantity as the operation angle of the intake valve becomes smaller. This allows the variation in the air-fuel ratio among the cylinders to be controlled more appropriately than when the fuel injection quantity is not corrected on the basis of the operation angle of the intake valve. More specifically, when a variation in the air-fuel ratio among the cylinders is detected, the control apparatus calculates a fuel injection quantity correction coefficient for reducing such variation, and also calculates a

relationship between the calculated fuel injection quantity correction coefficient and the operation angle of the intake valve upon calculation of the fuel injection quantity correction coefficient. When the operation angle of the intake valve has changed, the control apparatus then updates the fuel injection quantity correction coefficient on the basis of the changed operation angle of the intake valve and the calculated relationship. The relationship between the fuel injection quantity correction coefficient and the operation angle of the intake valve can be represented by a relation formula or a map, for example.

Brief Summary Text (52):
In the control apparatus, the controller reduces a variation in the air-fuel ratio among the cylinders by correcting a fuel injection quantity of each of the cylinders independently when an amount of correction of the calculated fuel injection quantity is smaller than a predetermined value, and guards the amount for correcting the calculated fuel injection quantity, corrects the target air-fuel ratio, and uniformly corrects each of the fuel injection quantity of all the cylinders on the basis of the corrected target air-fuel ratio when an amount of correction of the calculated fuel injection quantity is larger than the predetermined value.

Description Paragraph (21):
FIG. 19 is a graph showing a relationship between the fuel injection quantity correction coefficient and the operation angle of an intake valve;

Description Paragraph (22):
FIG. 20 is a flow chart showing a method for controlling so as to correct the target air-fuel ratio according to a ninth embodiment;

Description Paragraph (37):
In the foregoing exemplary embodiments and modifications thereof, when the air-fuel ratio of a cylinder among a plurality of cylinders Nos. 1 through 4, is calculated based on a value output from the air-fuel ratio sensor 57 and the valve lift amount of the intake valve 2 and/or exhaust valve 3 of each cylinder is controlled, a variation in the air-fuel ratio between cylinders is able to be reduced. If variation in the fuel injection quantity exists between cylinders, however, even if the variation in the air-fuel ratio between cylinders is reduced, a variation in torque between cylinders is generated, resulting in a pulsation (torque variation). Therefore, according to the first and second exemplary embodiments and modifications thereof, control such as that to be described later is performed to both reduce variation in the air-fuel ratio between cylinders and reduce variation in the torque between cylinders.

Description Paragraph (40):
Next in Step 104, a variation rate Qrate-n of the fuel injection quantity is calculated based on the variation .DELTA.Qn in the fuel injection quantity between the cylinders calculated in Step 103. Then in Step 105, the fuel injection quantity of each of the cylinders Nos. 1 through 4 is corrected so as to eliminate or reduce the variation in the fuel injection quantity among the cylinders.

Description Paragraph (42):
Further, according to the foregoing embodiments, when it is determined in Step 100 that the intake air amount to be introduced into the cylinder No. 1 upon calculation of the exhaust gas air-fuel ratio is the same as that to be introduced into the other cylinders Nos. 2 through 4 upon calculation of the exhaust gas air-fuel ratios, variation in the fuel injection quantity among the cylinders is minimized in Step 105 by the exhaust gas air-fuel ratio. That is, after making the intake air amount in all of the cylinders the same, the fuel injection quantity is corrected such that the exhaust gas air-fuel ratios in all of the cylinders are the same. This makes it possible to reduce both the variation in the air-fuel ratio among cylinders and the variation in the torque among cylinders.

Description Paragraph (46):
Also according to the exemplary embodiments and modifications thereof, the variation among cylinders is able to be reduced based on the operation angle of the intake valve. More specifically, the variation in the fuel injection quantity among cylinders can be reduced by the operation angle of the intake valve. Even more specifically, when it is determined in Step 100 in FIG. 11 that the operation angle of the intake valve assumes a maximum value, the variation in the fuel injection quantity between the cylinders is minimized in Step 105. Therefore, when it is possible to change the operation angle of the intake valve, it is possible to control the variation in the air-fuel ratio between the cylinders more appropriately than when the variation between cylinders is not controlled by the operation angle of the intake valve. In other words, it is possible to appropriately control the variation in the air-fuel ratio among the cylinders.

Description Paragraph (47):
A routine according to the method for learning intake valve operation angle variation, according to the embodiment for controlling the third type of the internal combustion engine and a modification thereof shown in FIG. 12 is executed at predetermined intervals, just as the routine shown in FIG. 11. In FIG. 12, when this routine starts, it is first determined in Step 150 whether the correction control in Step 105 in FIG. 11 has been completed. If the correction of the fuel injection quantity for all of the cylinders is not yet complete, then it is determined that the variation in the operation angle of the intake valve 2 among the cylinders can not be reduced and the routine ends. If the correction of the fuel injection quantity for all of the cylinders is complete, then the process proceeds to Step 151. In Step 151, it is determined whether the operation angle of the intake valve 2 is equal to or less than a predetermined threshold value. That is, it is determined whether the operation angle of the intake valve 2 is set to a relatively small value such that the intake air amount to be introduced into the cylinder is limited by the operation angle of the intake valve 2, and not limited by the opening amount of the throttle valve 56. If the determination is "NO", the routine ends. If the determination is "YES", the process proceeds to Step 152.

Description Paragraph (50):
According to the embodiment for controlling the third type of the internal combustion engine, after reducing the variation in the fuel injection quantity between the cylinders in Step 105 in FIG. 11, when it is determined in Step 151 that the valve opening characteristics of the intake valve 2 are set so that the intake air amount to be introduced into the cylinder is limited by the valve opening characteristics of the intake valve 2, and not limited by the opening amount of the throttle valve 56, the process proceeds to Step 153. In Step 153, the exhaust gas air-fuel ratio of that cylinder is calculated and then in Step 156 the variation in the valve opening characteristics of the intake valve 2 among cylinders is reduced by that exhaust gas air-fuel ratio. That is, after reducing the variation in the fuel injection quantity among the cylinders, the valve opening characteristics of the intake valve 2 of each of the cylinders Nos. 1 through 4 are changed such that the exhaust gas air-fuel ratio of the cylinder No. 1 and the exhaust gas air-fuel ratios of the other cylinders Nos. 2 through 4 are the same. Therefore, even if there is variation in the fuel intake quantity among the cylinders, no variation in torque among cylinders is generated and variation in the valve opening characteristics of the intake valve 2 among the cylinders can be reduced.

Description Paragraph (51):
Also, according to a modification of the embodiment, after reducing the variation in the fuel injection quantity among the cylinders in Step 105 in FIG. 11, when it is determined in Step 151 that the valve opening characteristics of the intake valve 2 are set so that the intake air amount to be introduced into the cylinder is limited by the valve opening characteristics of the intake valve 2, and not limited

by the cross-sectional area of the portion of the intake pipes 51 and 52 having the smallest internal circumference, the process proceeds to Step 153. In Step 153, the exhaust gas air-fuel ratio of that cylinder is calculated and then in Step 156, the variation in the valve opening characteristics of the intake valve 2 among cylinders is reduced by that exhaust gas air-fuel ratio. That is, after reducing the variation in the fuel injection quantity among the cylinders, the valve opening characteristics of the intake valve 2 of each of the cylinders Nos. 1 through 4 are changed such that the exhaust gas air-fuel ratio of the cylinder No. 1 and the exhaust gas air-fuel ratios of the other cylinders Nos. 2 through 4 are the same. Therefore, even if there is variation in the fuel intake quantity among cylinders, no variation in torque among cylinders is generated and the variation in the valve opening characteristics of the intake valves 2 among the cylinders can be reduced.

Description Paragraph (52):
More specifically, according to the embodiment for controlling the third type of the internal combustion engine and the modification thereof, after reducing the variation in the fuel injection quantity among the cylinders in Step 105 in FIG. 11, when it is determined in Step 151 that the operation angle of the intake valve 2 is set to a predetermined angle which is smaller than the maximum operation angle, the process proceeds to Step 153. In Step 153, the exhaust gas air-fuel ratio is calculated and then in Step 156, the variation in the operation angle of the intake valve 2 among the cylinders is reduced by that exhaust gas air-fuel ratio. That is, after reducing the variation in the fuel injection quantity among the cylinders, the operation angle of the intake valve 2 of each of the cylinders Nos. 1 through 4 is changed such that the exhaust gas air-fuel ratio of the cylinder No. 1 and the exhaust gas air-fuel ratios of the other cylinders Nos. 2 through 4 are the same. Therefore, even if there is variation in the fuel intake quantity among cylinders, no variation in torque among cylinders is generated and the variation in the operation angle of the intake valve 2 among the cylinders can be reduced.

Description Paragraph (53):
According to the foregoing embodiment and the modification thereof, after reducing the variation in the fuel injection quantity among the cylinders in Step 105 in FIG. 11, when it is determined in Step 151 that the operation angle of the intake valve 2 is set to a predetermined operation angle that is smaller than the maximum operation angle, the process proceeds to Step 153. In Step 153, the exhaust gas air-fuel ratio is calculated and then in Step 156, the variation in the intake air amount among cylinders is reduced by that exhaust gas air-fuel ratio. That is, after reducing the variation in the fuel injection quantity among the cylinders, the operation angle of the intake valve 2 of each of the cylinders Nos. 1 through 4 is changed such that the exhaust gas air-fuel ratio of the cylinder No. 1 and the exhaust gas air-fuel ratios of the other cylinders Nos. 2 through 4 are the same. Therefore, even if there is variation in the fuel intake quantity among the cylinders, no variation in torque among cylinders is generated and the variation in the intake air amount among the cylinders can be reduced.

Description Paragraph (58):
According to the embodiment for controlling the first and second type of the internal combustion engines, after reducing the variation in the fuel injection quantity among the cylinders in Step 105 shown in FIG. 11, when it is determined in Step 151 shown in FIG. 13 that the valve opening characteristics of the intake valve 2 are set such that the intake air amount to be introduced into the cylinder is limited by the valve opening characteristics of the intake valve 2, and not limited by the opening amount of the throttle valve 56, the process proceeds to Step 153. In Step 153, the exhaust gas air-fuel ratio of that cylinder is calculated and then in Step 250 and Step 251, the fuel injection quantity and the ignition timing, respectively, are corrected so as to reduce the variation in torque among cylinders.

Description Paragraph (59):
According to the foregoing embodiments and modifications thereof, after reducing the variation in the fuel injection quantity among the cylinders in Step 105 shown in FIG. 11, when it is determined in Step 151 in FIG. 13 that the valve opening characteristics of the intake valve 2 are set so that the intake air amount to be introduced into the cylinder is limited by the valve opening characteristics of the intake valve 2, and not limited by the cross-sectional area of the portion of the intake pipes 51 and 52 having the smallest internal circumference, the process proceeds to Step 153. In Step 153, the exhaust gas air-fuel ratio of that cylinder is calculated and then in Step 250 and Step 251 the fuel injection quantity and ignition timing, respectively, are corrected so as to reduce the variation in torque among the cylinders.

Description Paragraph (64):
Next in Step 104, a variation rate Qrate-n of the fuel injection quantity is calculated based on the variation .DELTA.Qn in the fuel injection quantity among the cylinders calculated in Step 103, just as was shown in FIG. 11. Then in Step 105, the fuel injection quantity of each of the cylinders Nos. 1 through 4 is corrected so as to reduce the variation in the fuel injection quantity among the cylinders, just as was shown in FIG. 11.

Description Paragraph (66):
Further, in the embodiments, when it is determined in Step 300 that the intake air amount to be introduced into the cylinder No. 1 when the exhaust gas air-fuel ratio thereof is calculated and the intake air amount to be introduced into the other cylinders Nos. 2 through 4 when the exhaust gas air-fuel ratios thereof are calculated are the same, the variation in the fuel injection quantity among the cylinders is reduced in Step 105 based on the exhaust gas air-fuel ratio. That is, after making the intake air amount in all of the cylinders the same, the fuel injection quantity is corrected such that the exhaust gas air-fuel ratios in all of the cylinders are the same. This allows both the variation in the air-fuel ratio among cylinders, as well as the variation in the torque among cylinders, to be reduced.

Description Paragraph (70):
Also, according to the foregoing embodiments and modifications, the variation among cylinders is able to be reduced based on the valve overlap amount of the intake valve 2 and the exhaust valve 3. More specifically, the variation in the fuel injection quantity among cylinders can be reduced based on the valve overlap amount of the intake valve 2 and the exhaust valve 3. Even more specifically, when it is determined in Step 300 in FIG. 14 that the valve overlap amount of the intake valve 2 and the exhaust valve 3 is set to the minimum value, the variation in the fuel injection quantity among the cylinders is reduced in Step 105. Therefore, when it is possible to change the valve overlap amount of the intake valve and the exhaust valve, the variation in the air-fuel ratio among the cylinders can be controlled more appropriately than when the variation among cylinders is not reduced based on the valve overlap amount of the intake valve and the exhaust valve. In other words, it is possible to appropriately control the variation in the air-fuel ratio among the cylinders.

Description Paragraph (71):
A routine according to the method for learning valve overlap amount variation, according to another embodiment and a modification thereof, in FIG. 15 is executed at predetermined intervals, just as the routine shown in FIG. 14. Referring to FIG. 15, when this routine starts, it is first determined in Step 150 whether the control in Step 105 in FIG. 14 has been completed. If the correction of the fuel injection quantity for all of the cylinders is not yet complete, it is determined that the variation in the valve overlap amount of the intake valve 2 and the exhaust valve 3 among the cylinders can not be reduced and the routine ends. If the correction of the fuel injection quantity for all of the cylinders is complete,

then the process proceeds to Step 450. In Step 450, it is determined whether the valve overlap amount of the intake valve 2 and the exhaust valve 3 is equal to or greater than a predetermined threshold value. That is, it is determined whether the valve overlap amount of the intake valve 2 and the exhaust valve 3 is set to a relatively large value such that the intake air amount to be introduced into the cylinder is limited by the valve overlap amount of the intake valve 2 and the exhaust valve 3, and not limited by the opening amount of the throttle valve 56. If the determination in step 450 is "NO", the routine ends. If the determination is "YES", the process proceeds to Step 152.

Description Paragraph (74):
According to the embodiment, after reducing the variation in the fuel injection quantity among the cylinders in Step 105 in FIG. 14, when it is determined in Step 450 in FIG. 15 that the valve opening characteristics of the intake valve 2 and the exhaust valve 3 are set so that the intake air amount to be introduced into the cylinder is limited by the valve opening characteristics of the intake valve 2 and the exhaust valve 3, and not limited by the opening amount of the throttle valve 56, the process proceeds to Step 153. In Step 153, the exhaust gas air-fuel ratio of that cylinder is calculated and then in Step 452, the variation in the valve opening characteristics of the intake valve 2 and the exhaust valve 3 among cylinders is reduced based on that exhaust gas air-fuel ratio. That is, after reducing the variation in the fuel injection quantity among the cylinders, the valve opening characteristics of the intake valves 2 and exhaust valves 3 of each of the cylinders Nos. 1 through 4 are changed such that the exhaust gas air-fuel ratio of the cylinder No. 1 and the exhaust gas air-fuel ratios of the other cylinders Nos. 2 through 4 are the same. Therefore, even if there is variation in the fuel intake quantity among cylinders, no variation in torque among cylinders is generated and the variation in the valve opening characteristics of the intake valves 2 and exhaust valves among the cylinders can be reduced.

Description Paragraph (75):
Also according to a modification of the embodiment, after reducing the variation in the fuel injection quantity among the cylinders in Step 105 in FIG. 14, when it is determined in Step 450 in FIG. 15 that the valve opening characteristics of the intake valve 2 and the exhaust valve 3 are set so that the intake air amount to be introduced into the cylinder is limited by the valve opening characteristics of the intake valve 2 and the exhaust valve 3, and not limited by the cross-sectional area of the portion of the intake pipes 51 and 52 having the smallest internal circumference, the process proceeds to Step 153. In Step 153, the exhaust gas air-fuel ratio of that cylinder is calculated and then in Step 452, the variation in the valve opening characteristics of the intake valve 2 and exhaust valve 3 among cylinders is reduced based on that exhaust gas air-fuel ratio. That is, after reducing the variation in the fuel injection quantity among the cylinders, the valve opening characteristics of the intake valves 2 and exhaust valves 3 of each of the cylinders Nos. 1 through 4 are changed such that the exhaust gas air-fuel ratio of the cylinder No. 1 and the exhaust gas air-fuel ratios of the other cylinders Nos. 2 through 4 are the same. Therefore, even if there is variation in the fuel intake quantity among cylinders, no variation in torque among cylinders is generated and the variation in the valve opening characteristics of the intake valves 2 and exhaust valves 3 among the cylinders can be reduced.

Description Paragraph (76):
More specifically, according to the embodiment and the modification thereof, after reducing the variation in the fuel injection quantity among the cylinders in Step 105 in FIG. 14, when it is determined in Step 450 in FIG. 15 that the valve overlap amount of the intake valve 2 and the exhaust valve 3 is set to the minimum value, the process proceeds to Step 153. In Step 153, the exhaust gas air-fuel ratio is calculated and then in Step 451, the variation in the valve overlap amount of the intake valve 2 and the exhaust valve 3 among cylinders is reduced based on that exhaust gas air-fuel ratio. That is, after reducing the variation in the fuel

injection quantity among the cylinders, the valve overlap amount of the intake valve 2 and the exhaust valve 3 of each of the cylinders Nos. 1 through 4 is changed such that the exhaust gas air-fuel ratio of the cylinder No. 1 and the exhaust gas air-fuel ratios of the other cylinders Nos. 2 through 4 are the same. Therefore, even if there is variation in the fuel intake quantity among cylinders, no variation in torque among cylinders is generated and the variation in the valve overlap amount of the intake valve 2 and the exhaust valve 3 among the cylinders can be reduced.

Description Paragraph (77):
In other words, according to the embodiment and the modification thereof, after reducing the variation in the fuel injection quantity among the cylinders in Step 105 in FIG. 14, when it is determined in Step 450 in FIG. 15 that the valve overlap amount of the intake valve 2 and the exhaust valve 3 is set to a predetermined valve overlap amount that is larger than the minimum valve overlap amount, the process proceeds to Step 153. In Step 153, the exhaust gas air-fuel ratio is calculated and then in Step 452 the variation in the intake air amount among cylinders is reduced with that exhaust gas air-fuel ratio. That is, after reducing the variation in the fuel injection quantity among the cylinders, the valve overlap amount of the intake valve 2 and the exhaust valve 3 of each of the cylinders Nos. 1 through 4 is changed such that the exhaust gas air-fuel ratio of the cylinder No. 1 and the exhaust gas air-fuel ratios of the other cylinders Nos. 2 through 4 are the same. Therefore, even if there is variation in the fuel intake quantity between cylinders, no variation in torque between cylinders is generated and the variation in the intake air amount between the cylinders can be reduced.

Description Paragraph (82):
According to the foregoing embodiments, after reducing the variation in the fuel injection quantity among the cylinders in Step 105 in FIG. 14, when it is determined in Step 450 in FIG. 16 that the valve opening characteristics of the intake valve 2 and the exhaust valve 3 are set so that the intake air amount to be introduced into the cylinder is limited by the valve opening characteristics of the intake valve 2 and the exhaust valve 3, and not limited by the opening amount of the throttle valve 56, the process proceeds to Step 153. In Step 153, the exhaust gas air-fuel ratio of that cylinder is calculated and then in Step 250 and Step 251, the fuel injection quantity and ignition timing, respectively, are corrected so as to reduce the variation in torque among the cylinders.

Description Paragraph (83):
Also according to the foregoing embodiments and modifications thereof, after reducing the variation in the fuel injection quantity among the cylinders in Step 105 in FIG. 14, when it is determined in Step 450 in FIG. 16 that the valve opening characteristics of the intake valve 2 and the exhaust valve 3 are set so that the intake air amount to be introduced into the cylinder is limited by the valve opening characteristics of the intake valve 2 and the exhaust valve 3, and not limited by the cross-sectional area of the portion of the intake pipes 51 and 52 having the smallest internal circumference, the process proceeds to Step 153. In Step 153, the exhaust gas air-fuel ratio of that cylinder is calculated and then in Step 250 and Step 251, the fuel injection quantity and ignition timing, respectively, are corrected so as to reduce the variation in torque among cylinders.

Description Paragraph (84):
Also according to the foregoing embodiments and modifications thereof, the variation among cylinders is controlled by the valve overlap amount of the intake valve and the exhaust valve. More specifically, when it is determined in Step 450 in FIG. 16 that the valve overlap amount of the intake valve 2 and the exhaust valve 3 is equal to or greater than a predetermined threshold value, the variation in the air-fuel ratio among the cylinders is reduced in Step 250. Therefore, when it is possible to change the valve overlap amount of the intake valve and the

exhaust valve, the variation in the air-fuel ratio among the cylinders can be controlled more appropriately than when the variation in the air-fuel ratio among the cylinders is controlled irrespective of the aforementioned threshold. In other words, it is possible to appropriately control the variation in the air-fuel ratio among the cylinders.

Description Paragraph (91):
Next in Step 504, a fuel injection quantity correction coefficient map, which shows the relationship between the fuel injection quantity correction coefficient and the operation angle of the intake valve 2, is created based on the fuel injection amount quantity correction coefficient calculated in Step 503 and the operation angle of the intake valve 2 at that time. As shown in FIG. 19, when a point P1 is calculated in Step 503, a curved line L1 showing the relationship between the fuel injection quantity correction coefficient and the operation angle of the intake valve is calculated from that point P1, and a fuel injection quantity correction coefficient map is created based on that curved line L1. According to a modification of the eighth embodiment, in Step 504 it is possible to calculate a relational expression that simplifies the curved line L1 instead of creating the map. Also according to a modification of the embodiment, it is possible to calculate not only the point P1 but also a point P1' in a step similar to Step 503, calculate a curved line similar to the curved line L1 based on the point P1 and the point P1', and then create a fuel injection quantity correction coefficient map based on that curved line.

Description Paragraph (94):
According to the embodiment or the modification thereof, a variation between cylinders is reduced by the operation angle of the intake valve 2. More specifically, as shown in FIG. 19, the variation in the fuel injection quantity among cylinders is reduced by calculating the fuel injection quantity correction coefficient of each cylinder No. 1 through 4based on the operation angle of the intake valve 2, and correcting the fuel injection quantity in each cylinder No. 1 through 4 in Step 505 based on that fuel injection quantity correction coefficient. Therefore, when it is possible to change the operation angle of the intake valve, it is possible to control the variation in the air-fuel ratio among the cylinders more appropriately than when the variation between cylinders is not controlled by the operation angle of the intake valve.

Description Paragraph (96):
Also, according to the embodiment or the modification thereof, the variation in the air-fuel ratio among the cylinders is reduced by correcting the fuel injection quantity in Step 505 based on the operation angle of the intake valve 2. For example, when the air-fuel ratio of a cylinder varies to the rich side, the variation in the air-fuel ratio among the cylinders is reduced by correcting with a decrease the fuel injection quantity of that cylinder. Also, the smaller the operation angle of the intake valve, the greater the variation in the air-fuel ratio among cylinders when the actual operation angle is off from the target operation angle. In view of this, as shown in FIG. 19, the difference between the fuel injection quantity correction coefficient and 1.0 is made to become larger as the operation angle of the intake valve becomes smaller. As a result, the variation in the air-fuel ratio among the cylinders is controlled by increasing the correction amount of the fuel injection quantity. This enables the variation in the air-fuel ratio among cylinders to be controlled more appropriately than when the fuel injection quantity is not corrected by the operation angle of the intake valve.

Description Paragraph (102):
Next in Step 603, the target air-fuel ratio map showing the relationship between the corrected target air-fuel ratio and the operation angle of the intake valve 2 is created based on the corrected target air-fuel ratio calculated in Step 602 and the operation angle of the intake valve 2 at that time. As shown in FIG. 21, when a

point P2 is calculated in Step 602, a curved line L2 showing the relationship between the corrected target air-fuel ratio and the operation angle of the intake valve is calculated from that point P2. The target air-fuel ratio map is then created based on that curved line L2. According to a modification of the ninth embodiment of the invention, in Step 603 it is possible to calculate a relational expression that simplifies the curved line L2 instead of creating the map. Also according to another modification of the embodiment, it is possible to calculate not only the point P2 but also a point P2' in a step similar to Step 602, calculate a curved line similar to the curved line L2 based on the point P2 and the point P2', and then create a fuel injection quantity correction coefficient map based on that curved line.

Description Paragraph (105):
That is, when the corrected target air-fuel ratio shifts over to the lean side, for example, the feedback correction quantity is reduced such that the fuel injection quantity is corrected with a reduction. On the other hand, when the corrected target air-fuel ratio shifts over to the rich side, for example, the feedback correction quantity is increased such that the fuel injection quantity is corrected with an increase.

Description Paragraph (120):
The embodiment has substantially the same effects and advantages as the eighth and ninth embodiments. Moreover, according to the embodiment, in consideration of the possibility that a large torque variation may be generated if the correction amount of the fuel injection quantity is large, when it is determined in Step 700 that the calculated correction amount of the fuel injection quantity is small, the control apparatus individually corrects the fuel injection quantity in each of the cylinders Nos. 1 through 4 in Step 505, thereby minimizing the variation in the air-fuel ratio among the cylinders. On the other hand, when it is determined in Step 700 that the calculated correction amount of the fuel injection quantity is large, the correction amount of the fuel injection quantity is guarded by a predetermined value in Step 701. A corrected target air-fuel ratio is then calculated in Steps 602 and 603 and the fuel injection quantity of all of the cylinders Nos. 1 through 4 are uniformly corrected by that corrected target air-fuel ratio in Step 604. That is, air-fuel ratio feedback control is performed, such that torque variation is reduced while the air-fuel ratio is able to be appropriately controlled.

Description Paragraph (122):
According to the invention, by making the throttle valve opening amount in one cylinder when the exhaust gas air-fuel ratio of that cylinder is calculated and the throttle valve opening amount in another cylinder when the exhaust gas air-fuel ratio of that cylinder is calculated substantially the same, the intake air amount introduced into the one cylinder when the exhaust gas air-fuel ratio of that cylinder is calculated and the intake air amount introduced into the other cylinder when the exhaust gas air-fuel ratio of that cylinder is calculated are able to made the same. Furthermore, while a variation in the air-fuel ratio among cylinders can be reduced just as in the control apparatus for a multi-cylinder internal combustion engine disclosed in Japanese Patent Application Laid-Open Publication No. 6-213044, a pulsation generated by a variation in torque among cylinders when there is a variation in fuel injection quantity among cylinders can be avoided. That is, a variation in air-fuel ratio among cylinders as well as a variation in torque among cylinders can be reduced.

Description Paragraph (123):
According to an aspect of the invention, a variation in the intake air amount among cylinders can be reduced without generating a variation in torque among cylinders even if there is a variation in the fuel injection quantity between cylinders.

Description Paragraph (125):

According to another aspect of the invention, a variation in the operation angle of the intake valve among cylinders can be reduced without generating a variation in torque among cylinders even if there is a variation in the fuel injection quantity among cylinders.

Description Paragraph (128):
According to another aspect of the invention, a variation in the air-fuel ratio among cylinders can be controlled more appropriately than with the control apparatus for a multi-cylinder internal combustion engine disclosed in Japanese Patent Application Laid-Open Publication No. 6-213044, in which a variation among cylinders cannot be reduced based on the operation angle of the intake valve, when the operation angle of the intake valve can be changed. In other words, it is possible to appropriately control the variation in the air-fuel ratio among the cylinders.

Current US Cross Reference Classification (6):
701/103

CLAIMS:

1. A control apparatus for a multi-cylinder internal combustion engine including a plurality of cylinders, the control apparatus comprising a controller that: calculates an exhaust gas air-fuel ratio of a cylinder when valve opening characteristics of an intake valve and an exhaust valve of each of the cylinders of the internal combustion engine are set such that an amount of an intake air introduced into the cylinder is not limited by the valve opening characteristics; and reduces a variation in a fuel injection quantity among the plurality of cylinders on the basis of the calculated exhaust gas air-fuel ratio of each of the cylinders.

3. A control apparatus according to claim 1, wherein the controller: calculates the exhaust gas air-fuel ratio of the cylinder when the valve opening characteristics of the intake valve and the exhaust valve are set such that the amount of the intake air introduced into the cylinder is limited by the valve opening characteristics after reducing the variation in the fuel injection quantity among the plurality of cylinders; and reduces a variation in the valve opening characteristics of the intake valve and the exhaust valve among the plurality of cylinders on the basis of the calculated exhaust gas air-fuel ratio of the cylinder.

6. A control apparatus for a multi-cylinder internal combustion engine including a plurality of cylinders, the control apparatus comprising a controller that: calculates an exhaust gas air-fuel ratio of each of the cylinders when an operation angle of an intake valve of each cylinder of the internal combustion engine is set to a predetermined angle; and reduces a variation in a fuel injection quantity among the plurality of cylinders on the basis of the calculated exhaust gas air-fuel ratio of each of the cylinders.

10. A control apparatus according to claim 6, wherein the controller: calculates the exhaust gas air-fuel ratio of each of the cylinders when valve opening characteristics of the intake valve and an exhaust valve are set such that an amount of intake air introduced into each of the cylinders is limited by the valve opening characteristics after reducing the variation in the fuel injection quantity among the plurality of cylinders; and reduces a variation in the valve opening characteristics of the intake valve and the exhaust valve among the plurality of cylinders on the basis of the calculated exhaust gas air-fuel ratio of each of the cylinders.

11. A control apparatus according to claim 6, wherein the controller: calculates the exhaust gas air-fuel ratio of each of the cylinders when the operation angle of

the intake valve is set to an operation angle that is smaller than the predetermined angle after reducing the variation in the fuel injection quantity among the plurality of cylinders; and reduces a variation in the amount of the intake air among the plurality of cylinders on the basis of the calculated exhaust gas air-fuel ratio of each of the cylinders.

12. A control apparatus according to claim 6, wherein the controller: calculates the exhaust gas air-fuel ratio of each of the cylinders when the operation angle of the intake valve is set to an operation angle that is smaller than the predetermined angle after reducing the variation in the fuel injection quantity among the plurality of cylinders; and reduces a variation in the operation angle of the intake valve among the cylinders on the basis of the calculated exhaust gas air-fuel ratio of each of the cylinders.

13. A control apparatus for a multi-cylinder internal combustion engine, the control apparatus comprising a controller that: calculates an exhaust gas air-fuel ratio of each of the cylinders when a valve overlap amount of an intake valve and an exhaust valve of each of the cylinders of the internal combustion engine is set to a predetermined amount; and reduces a variation in a fuel injection quantity among the plurality of cylinders on the basis of the calculated exhaust gas air-fuel ratio of each of the cylinders.

Previous Doc Next Doc Go to Doc#

L44: Entry 14 of 45 File: USPT Jul 11, 2006

DOCUMENT-IDENTIFIER: US 7073493 B2
TITLE: Control apparatus for multi-cylinder internal combustion engine and control method

PRIOR-PUBLICATION:

DOC-ID	DATE
US 20020104520 A1	August 8, 2002

Abstract Text (1):
A control apparatus calculates a exhaust gas air-fuel ratio of a plurality of cylinders, in which the operation angle of an intake valve is set to a predetermined operation angle, e.g., a maximum operation angle, based on a value output from an air-fuel ratio sensor so as to minimize a variation in an fuel injection quantity between the plurality of cylinders by that exhaust gas air-fuel ratio. That is, the exhaust gas air-fuel ratio of the plurality of cylinders, in which the valve opening characteristics of the intake valve and an exhaust valve are set such that the intake air amount to be introduced into the plurality of cylinders is limited by the opening amount of a throttle valve, for example, and not limited by the valve opening characteristics of the intake valve or the exhaust valve is calculated, and the variation in the fuel injection quantity among the plurality of cylinders is then reduced by that exhaust gas air-fuel ratio. Then, the variation in valve opening characteristics among the cylinders is reduced.

Brief Summary Text (7):
Conventionally, a control apparatus for a multi-cylinder internal combustion engine, which reduces variation in the air-fuel ratio between cylinders is known. An example of this type of control apparatus is disclosed in Japanese Patent Application Laid-Open Publication No. 6-213044. The control apparatus disclosed in this publication calculates the air-fuel ratio of each of a plurality of cylinders based on a value output from an air-fuel sensor. Any variation in the air-fuel ratios between the cylinders is then minimized by controlling the valve lift amount of each of the cylinders.

Brief Summary Text (14):
According to one aspect of the invention, a control apparatus for a multicylinder internal combustion engine including a plurality of cylinders is provided with a controller that calculates an exhaust gas air-fuel ratio of a cylinder when valve opening characteristics of an intake valve and an exhaust valve of each of the cylinders of the internal combustion engine are set such that an amount of an intake air introduced into the cylinder is not limited by the valve opening characteristics; and reduces a variation in a fuel injection quantity among the cylinders on the basis of the calculated exhaust gas air-fuel ratio of each of the cylinders.

Brief Summary Text (16):
In the control apparatus, when the valve opening characteristics of the intake valve and the exhaust valve of the cylinder are set so as not to limit the quantity of air introduced into the cylinder, the exhaust gas air-fuel ratio of the cylinder is calculated. Preferably, when the valve opening characteristics of the intake

valve and the exhaust valve of the cylinder are set such that the quantity of air introduced into the cylinder is limited by the throttle valve opening amount and not limited by the valve opening characteristics, the exhaust gas air-fuel ratio of the cylinder is calculated. In order to calculate an exhaust gas air-fuel ratio of each of the cylinders, the valve opening characteristics of the intake valve and the exhaust valve of the cylinder are set such that quantity of the intake air introduced into the cylinder is limited by the throttle valve opening amount and not limited by the valve opening characteristics of the intake and exhaust valves of the cylinder. In other words, the throttle valve opening amount of one cylinder upon calculation of the exhaust gas air-fuel ratio of the cylinder is made substantially equivalent to that of an other cylinder upon calculation of the exhaust gas air-fuel ratio of the other cylinder so as to make the quantity of the intake air introduced into the one cylinder upon calculation of the exhaust gas air-fuel ratio of the one cylinder equivalent to that of the other cylinder. Further in the invention, the amount of the intake air introduced into one cylinder upon calculation of the exhaust gas air-fuel ratio of the cylinder is made equivalent to that of the exhaust gas air fuel ratio of the other cylinder so as to obtain the exhaust gas air-fuel ratio of the cylinder. As a result, a variation in the fuel injection amount among the cylinders can be reduced on the basis of the exhaust gas air-fuel ratio. Accordingly, each amount of the intake air introduced into each of the cylinders is made equivalent, and then the respective fuel injection quantity is corrected so as to make each exhaust gas air-fuel ratio of the cylinders equivalent. Unlike the control apparatus disclosed in Japanese Patent Application Laid-Open Publication No. 6-213044, the variation in the air-fuel ratio among the cylinders is reduced while controlling a variation in torque among the cylinders when there is variation in the fuel injection quantity among the cylinders, thus preventing pulsation. That is, the control apparatus of this aspect of the invention reduces a variation in the air-fuel ratio among the cylinders as well as a variation in torque among the cylinders.

Brief Summary Text (17):
According to another aspect of the invention, a control apparatus for a multicylinder internal combustion engine including a plurality of cylinders is provided with a controller that calculates an exhaust gas air-fuel ratio of each of the cylinders when an operation angle of an intake valve of each of the cylinders of the internal combustion engine is set to a predetermined angle, and reduces a variation in a fuel injection quantity among the cylinders on the basis of the calculated exhaust gas air-fuel ratio of each of the cylinders.

Brief Summary Text (22):
In the control apparatus, the amount of the intake air introduced into one cylinder upon calculation of the exhaust gas air-fuel ratio of that cylinder is made equivalent to that of the other cylinder such that a variation in the fuel injection quantity can be minimized on the basis of the calculated exhaust gas air-fuel ratio. Accordingly, the amount of the intake air introduced to each of the cylinders is made equivalent and the fuel injection quantity is corrected so as to make the exhaust gas air-fuel ratio of each of the cylinders equivalent. Unlike the control apparatus disclosed in Japanese Patent Application Laid-Open Publication No. 6-213044, the variation in the air-fuel ratio among the cylinders can be reduced while controlling a variation in the torque among the cylinders in the presence of the variation in the fuel injection quantity among the cylinders, thus preventing pulsation. Accordingly, the variation both in the air-fuel ratio and in the torque among the cylinders can be reduced.

Brief Summary Text (23):
According to another aspect of the invention, a control apparatus for a multicylinder internal combustion engine is provided with a controller that calculates an exhaust gas air-fuel ratio of each of the cylinders when a valve overlap amount of an intake valve and an exhaust valve of each of the cylinders of the internal combustion engine is set to a predetermined amount, and reduces a

variation in a fuel injection quantity among the plurality of cylinders on the basis of the calculated exhaust gas air-fuel ratio of each of the cylinders.

Brief Summary Text (27):
In the control apparatus according to another aspect of the invention, an exhaust gas air-fuel ratio of each of the cylinders is calculated in which a valve overlap amount of the intake valve and the exhaust valve is set to a predetermined amount. More specifically, the control apparatus calculates the exhaust gas air-fuel ratio of each of the cylinders in which the overlap amount of the intake valve and the exhaust valve is set so as not to limit the quantity of air introduced into the cylinders. Preferably, the control apparatus calculates the exhaust gas air-fuel ratio of each of the cylinders in which the valve overlap amount of the intake valve and the exhaust valve is set such that the intake air amount introduced into the cylinders is limited by the throttle valve opening amount, and is not limited by the valve overlap amount of the intake valve and the exhaust valve. Most preferably, the control apparatus calculates the exhaust gas air-fuel ratio of each of the cylinders in which the valve overlap amount of the intake valve and the exhaust valve is set to a minimum valve overlap amount. That is, the control apparatus calculates the exhaust gas air-fuel ratio of a certain cylinder, when the valve overlap amount of the intake valve and the exhaust valve is set to the minimum amount so that the intake air amount introduced into that cylinder is limited by the throttle valve opening amount, and is not limited by the valve overlap amount. In other words, the intake air amount into a cylinder upon calculation of the exhaust gas air-fuel ratio of the cylinder is made equivalent to that of the other cylinder by making the throttle valve opening amount upon calculation of the exhaust gas air-fuel ratio of a cylinder substantially equivalent to that of the other cylinder. In the control apparatus, the variation in the fuel injection quantity among cylinders can be reduced by making the intake air amount into a cylinder upon calculation of the exhaust gas air-fuel ratio of the cylinder equivalent to that of the other cylinder. In other words, the intake air amount of all cylinders is made equivalent and the fuel injection quantity is corrected so as to make all the exhaust gas air-fuel ratios of the cylinders equivalent. Unlike Japanese Patent Application Laid-Open Publication No. 6-213044, the variation in the air-fuel ratio among the cylinders can be reduced while reducing the variation in the torque among the cylinders in the presence of the variation in the fuel injection quantity among the cylinders, thus preventing pulsation. More specifically, the control apparatus is capable of minimizing the variation both in the air-fuel ratio and the torque among the cylinders.

Brief Summary Text (28):
In the control apparatus according to another aspect of the invention, the controller calculates an exhaust gas air-fuel ratio of each of the cylinders when the valve opening characteristics of the intake valve and the exhaust valve are set such that the amount of the intake air introduced into the cylinder is limited by the valve opening characteristics after reducing the variation in the fuel injection quantity among the plurality of cylinders; and reduces a variation in the valve opening characteristics of the intake valve and the exhaust valve among the plurality of cylinders on the basis of the calculated exhaust gas air-fuel ratio of the cylinders.

Brief Summary Text (30):
The control apparatus according to another aspect of the invention calculates, after reducing the variation in the fuel injection quantity among the cylinders, the exhaust gas air-fuel ratio of a cylinder in which the valve opening characteristics of the intake valve and the exhaust valve are set so as to limit the intake air amount introduced into the cylinder, and then reduces the variation in the valve opening characteristics of the intake valve and the exhaust valve among the cylinders based on the set exhaust gas air-fuel ratio. More preferably, the control apparatus calculates, after reducing the variation in the fuel injection quantity among the cylinders, the exhaust gas air-fuel ratio of the

cylinder in which the valve opening characteristics of the intake valve and the exhaust valve are set such that the intake air amount introduced into the cylinder is limited by the valve opening characteristics of the intake valve or exhaust valve, and is not limited by the throttle valve opening amount, and then reduces the variation in the valve opening characteristics of the intake valve and the exhaust valve among the cylinders based on the calculated exhaust gas air-fuel ratio. That is, after reducing the variation in the fuel injection quantity among the cylinders, the control apparatus changes the valve opening characteristics of the intake valve and the exhaust valve of each cylinder so that the exhaust gas air-fuel ratio of one cylinder is made equivalent to that of another cylinder. The control apparatus is capable of reducing the variation in the valve opening characteristics of the intake valve and the exhaust valve among the cylinders without generating variation in the torque among the cylinders irrespective of the variation in the fuel injection quantity among the cylinders.

Brief Summary Text (31):
In the control apparatus, the controller calculates the exhaust gas air-fuel ratio of each of the cylinders when the operation angle of the intake valve is set to an operation angle that is smaller than the predetermined operation angle after reducing the variation in the fuel injection quantity among the cylinders, and reduces a variation in the amount of the intake air among the cylinders on the basis of the calculated exhaust gas air-fuel ratio of each of the cylinders.

Brief Summary Text (32):
The control apparatus of the invention calculates, after reducing the variation in the fuel injection quantity among the cylinders, the exhaust gas air-fuel ratio of each of the cylinders in which the operation angle of the intake valve is set to an operation angle smaller than the predetermined operation angle, and then reduces the variation in the intake air amount among the cylinders on the basis of the calculated exhaust gas air-fuel ratio. That is, after reducing the variation in the fuel injection quantity among the cylinders, the operation angle of the intake valve of each cylinder is changed such that the exhaust gas air-fuel ratio of one cylinder is made equivalent to that of another cylinder. The control apparatus is capable of reducing the variation in the intake air amount among the cylinders without generating variation in torque among the cylinders irrespective of the variation in the fuel injection quantity among the cylinders.

Brief Summary Text (33):
In the control apparatus, the controller calculates the exhaust gas air-fuel ratio of each of the cylinders when the operation angle of the intake valve is set to an operation angle that is smaller than the predetermined operation angle after reducing the variation in the fuel injection quantity among the cylinders, and reduces a variation in the operation angle of the intake valve among the cylinders on the basis of the calculated exhaust gas air-fuel ratio of each of the cylinders.

Brief Summary Text (34):
The control apparatus of the invention calculates, after reducing the variation in the fuel injection quantity among the cylinders, the exhaust gas air-fuel ratio of the cylinder in which the operation angle of the intake valve is set to an operation angle smaller than the predetermined operation angle, and then reduces the variation in the operation angle of the intake valve among the cylinders on the basis of the calculated exhaust gas air-fuel ratio. That is, after reducing the variation in the fuel injection quantity among the cylinders, the operation angle of the intake valve of each cylinder is changed such that the exhaust gas air-fuel ratio of one cylinder is made equivalent to that of another cylinder. The control apparatus is capable of reducing the variation in the intake air amount among the cylinders without generating a variation in torque among the cylinders irrespective of the variation in the fuel injection quantity among the cylinders.

Brief Summary Text (38):
In the control apparatus, the controller reduces a variation in a fuel injection quantity among the cylinders on the basis of the valve overlap amount of the intake valve and the exhaust valve of each of the cylinders.

Brief Summary Text (39):
The control apparatus of this aspect of the invention reduces the variation among the cylinders on the basis of a valve overlap amount of the intake valve and the exhaust valve. More specifically, the control apparatus reduces the variation in the fuel injection quantity among the cylinders on the basis of the valve overlap amount of the intake valve and the exhaust valve. The control apparatus of the invention is capable of reducing the variation in the air-fuel ratio among the cylinders more effectively when the valve overlap amount can be changed than the control apparatus for a multi-cylinder internal combustion engine disclosed in Japanese Patent Application Laid-Open Publication No. 6-213044, in which the variation among the cylinders cannot be reduced on the basis of the valve overlap amount of the intake valve and the exhaust valve. In other words, the control apparatus is capable of appropriately controlling the variation in the air-fuel ratio among the cylinders.

Brief Summary Text (41):
In the control apparatus, the controller reduces a variation in an air-fuel ratio among the cylinders on the basis of the operation angle of the intake valve of each of the cylinders.

Brief Summary Text (42):
The control apparatus of this aspect of the invention reduces a variation among the cylinders on the basis of an operation angle of the intake valve. More specifically, the control apparatus reduces the variation in the air-fuel ratio among the cylinders on the basis of the operation angle of the intake valve. Unlike the control apparatus for a multicylinder internal combustion engine disclosed in Japanese Patent Application Laid-Open Publication No. 6-213044, in which a variation between cylinders cannot be reduced on the basis of the operation angle of the intake valve, the control apparatus of the invention is capable of reducing the variation in the air-fuel ratio among the cylinders appropriately even when the operation angle of the intake valve is changed. The variation in the air-fuel ratio among the cylinders, thus, can be appropriately controlled.

Brief Summary Text (43):
In the control apparatus, the controller reduces a variation in the air-fuel ratio among the cylinders by correcting a fuel injection quantity on the basis of the operation angle of the intake valve.

Brief Summary Text (47):
The control apparatus as described above reduces the variation in the air-fuel ratio among the cylinders by correcting the fuel injection quantity on the basis of the operation angle of the intake valve. For example, when the air-fuel ratio of one cylinder varies on the rich side, the fuel injection quantity supplied to the cylinder is decreased so as to reduce the variation in the air-fuel ratio among the cylinders. Also, the smaller the operation angle of the intake valve becomes, the greater the variation in the air-fuel ratio becomes among the cylinders when the actual operation angle deviates from the target operation angle. In view of this, the variation in the air-fuel ratio among the cylinders can be reduced by executing correction, for example, increasing the fuel injection quantity as the operation angle of the intake valve becomes smaller. This allows the variation in the air-fuel ratio among the cylinders to be controlled more appropriately than when the fuel injection quantity is not corrected on the basis of the operation angle of the intake valve. More specifically, when a variation in the air-fuel ratio among the cylinders is detected, the control apparatus calculates a fuel injection quantity correction coefficient for reducing such variation, and also calculates a

relationship between the calculated fuel injection quantity correction coefficient and the operation angle of the intake valve upon calculation of the fuel injection quantity correction coefficient. When the operation angle of the intake valve has changed, the control apparatus then updates the fuel injection quantity correction coefficient on the basis of the changed operation angle of the intake valve and the calculated relationship. The relationship between the fuel injection quantity correction coefficient and the operation angle of the intake valve can be represented by a relation formula or a map, for example.

Brief Summary Text (54):
In the control apparatus, the controller reduces a variation in the air-fuel ratio among the cylinders by correcting a fuel injection quantity of each of the cylinders independently when an amount of correction of the calculated fuel injection quantity is smaller than a predetermined value, and guards the amount for correcting the calculated fuel injection quantity, corrects the target air-fuel ratio, and uniformly corrects each of the fuel injection quantity of all the cylinders on the basis of the corrected target air-fuel ratio when an amount of correction of the calculated fuel injection quantity is larger than the predetermined value.

Description Paragraph (21):
FIG. 19 is a graph showing a relationship between the fuel injection quantity correction coefficient and the operation angle of an intake valve;

Description Paragraph (22):
FIG. 20 is a flow chart showing a method for controlling so as to correct the target air-fuel ratio according to a ninth embodiment;

Description Paragraph (37):
In the foregoing exemplary embodiments and modifications thereof, when the air-fuel ratio of a cylinder among a plurality of cylinders Nos. 1 through 4, is calculated based on a value output from the air-fuel ratio sensor 57 and the valve lift amount of the intake valve 2 and/or exhaust valve 3 of each cylinder is controlled, a variation in the air-fuel ratio between cylinders is able to be reduced. If variation in the fuel injection quantity exists between cylinders, however, even if the variation in the air-fuel ratio between cylinders is reduced, a variation in torque between cylinders is generated, resulting in a pulsation (torque variation). Therefore, according to the first and second exemplary embodiments and modifications thereof, control such as that to be described later is performed to both reduce variation in the air-fuel ratio between cylinders and reduce variation in the torque between cylinders.

Description Paragraph (40):
Next in Step 104, a variation rate Qrate-n of the fuel injection quantity is calculated based on the variation .DELTA.Qn in the fuel injection quantity between the cylinders calculated in Step 103. Then in Step 105, the fuel injection quantity of each of the cylinders Nos. 1 through 4 is corrected so as to eliminate or reduce the variation in the fuel injection quantity among the cylinders.

Description Paragraph (42):
Further, according to the foregoing embodiments, when it is determined in Step 100 that the intake air amount to be introduced into the cylinder No. 1 upon calculation of the exhaust gas air-fuel ratio is the same as that to be introduced into the other cylinders Nos. 2 through 4 upon calculation of the exhaust gas air-fuel ratios, variation in the fuel injection quantity among the cylinders is minimized in Step 105 by the exhaust gas air-fuel ratio. That is, after making the intake air amount in all of the cylinders the same, the fuel injection quantity is corrected such that the exhaust gas air-fuel ratios in all of the cylinders are the same. This makes it possible to reduce both the variation in the air-fuel ratio among cylinders and the variation in the torque among cylinders.

Description Paragraph (46):
Also according to the exemplary embodiments and modifications thereof, the variation among cylinders is able to be reduced based on the operation angle of the intake valve. More specifically, the variation in the fuel injection quantity among cylinders can be reduced by the operation angle of the intake valve. Even more specifically, when it is determined in Step 100 in FIG. 11 that the operation angle of the intake valve assumes a maximum value, the variation in the fuel injection quantity between the cylinders is minimized in Step 105. Therefore, when it is possible to change the operation angle of the intake valve, it is possible to control the variation in the air-fuel ratio between the cylinders more appropriately than when the variation between cylinders is not controlled by the operation angle of the intake valve. In other words, it is possible to appropriately control the variation in the air-fuel ratio among the cylinders.

Description Paragraph (47):
A routine according to the method for learning intake valve operation angle variation, according to the embodiment for controlling the third type of the internal combustion engine and a modification thereof shown in FIG. 12 is executed at predetermined intervals, just as the routine shown in FIG. 11. In FIG. 12, when this routine starts, it is first determined in Step 150 whether the correction control in Step 105 in FIG. 11 has been completed. If the correction of the fuel injection quantity for all of the cylinders is not yet complete, then it is determined that the variation in the operation angle of the intake valve 2 among the cylinders can not be reduced and the routine ends. If the correction of the fuel injection quantity for all of the cylinders is complete, then the process proceeds to Step 151. In Step 151, it is determined whether the operation angle of the intake valve 2 is equal to or less than a predetermined threshold value. That is, it is determined whether the operation angle of the intake valve 2 is set to a relatively small value such that the intake air amount to be introduced into the cylinder is limited by the operation angle of the intake valve 2, and not limited by the opening amount of the throttle valve 56. If the determination is "NO", the routine ends. If the determination is "YES", the process proceeds to Step 152.

Description Paragraph (50):
According to the embodiment for controlling the third type of the internal combustion engine, after reducing the variation in the fuel injection quantity between the cylinders in Step 105 in FIG. 11, when it is determined in Step 151 that the valve opening characteristics of the intake valve 2 are set so that the intake air amount to be introduced into the cylinder is limited by the valve opening characteristics of the intake valve 2, and not limited by the opening amount of the throttle valve 56, the process proceeds to Step 153. In Step 153, the exhaust gas air-fuel ratio of that cylinder is calculated and then in Step 156 the variation in the valve opening characteristics of the intake valve 2 among cylinders is reduced by that exhaust gas air-fuel ratio. That is, after reducing the variation in the fuel injection quantity among the cylinders, the valve opening characteristics of the intake valve 2 of each of the cylinders Nos. 1 through 4 are changed such that the exhaust gas air-fuel ratio of the cylinder No. 1 and the exhaust gas air-fuel ratios of the other cylinders Nos. 2 through 4 are the same. Therefore, even if there is variation in the fuel intake quantity among the cylinders, no variation in torque among cylinders is generated and variation in the valve opening characteristics of the intake valve 2 among the cylinders can be reduced.

Description Paragraph (51):
Also, according to a modification of the embodiment, after reducing the variation in the fuel injection quantity among the cylinders in Step 105 in FIG. 11, when it is determined in Step 151 that the valve opening characteristics of the intake valve 2 are set so that the intake air amount to be introduced into the cylinder is limited by the valve opening characteristics of the intake valve 2, and not limited

by the cross-sectional area of the portion of the intake pipes 51 and 52 having the smallest internal circumference, the process proceeds to Step 153. In Step 153, the exhaust gas air-fuel ratio of that cylinder is calculated and then in Step 156, the variation in the valve opening characteristics of the intake valve 2 among cylinders is reduced by that exhaust gas air-fuel ratio. That is, after reducing the variation in the fuel injection quantity among the cylinders, the valve opening characteristics of the intake valve 2 of each of the cylinders Nos. 1 through 4 are changed such that the exhaust gas air-fuel ratio of the cylinder No. 1 and the exhaust gas air-fuel ratios of the other cylinders Nos. 2 through 4 are the same. Therefore, even if there is variation in the fuel intake quantity among cylinders, no variation in torque among cylinders is generated and the variation in the valve opening characteristics of the intake valves 2 among the cylinders can be reduced.

Description Paragraph (52):
More specifically, according to the embodiment for controlling the third type of the internal combustion engine and the modification thereof, after reducing the variation in the fuel injection quantity among the cylinders in Step 105 in FIG. 11, when it is determined in Step 151 that the operation angle of the intake valve 2 is set to a predetermined angle which is smaller than the maximum operation angle, the process proceeds to Step 153. In Step 153, the exhaust gas air-fuel ratio is calculated and then in Step 156, the variation in the operation angle of the intake valve 2 among the cylinders is reduced by that exhaust gas air-fuel ratio. That is, after reducing the variation in the fuel injection quantity among the cylinders, the operation angle of the intake valve 2 of each of the cylinders Nos. 1 through 4 is changed such that the exhaust gas air-fuel ratio of the cylinder No. 1 and the exhaust gas air-fuel ratios of the other cylinders Nos. 2 through 4 are the same. Therefore, even if there is variation in the fuel intake quantity among cylinders, no variation in torque among cylinders is generated and the variation in the operation angle of the intake valve 2 among the cylinders can be reduced.

Description Paragraph (53):
According to the foregoing embodiment and the modification thereof, after reducing the variation in the fuel injection quantity among the cylinders in Step 105 in FIG. 11, when it is determined in Step 151 that the operation angle of the intake valve 2 is set to a predetermined operation angle that is smaller than the maximum operation angle, the process proceeds to Step 153. In Step 153, the exhaust gas air-fuel ratio is calculated and then in Step 156, the variation in the intake air amount among cylinders is reduced by that exhaust gas air-fuel ratio. That is, after reducing the variation in the fuel injection quantity among the cylinders, the operation angle of the intake valve 2 of each of the cylinders Nos. 1 through 4 is changed such that the exhaust gas air-fuel ratio of the cylinder No. 1 and the exhaust gas air-fuel ratios of the other cylinders Nos. 2 through 4 are the same. Therefore, even if there is variation in the fuel intake quantity among the cylinders, no variation in torque among cylinders is generated and the variation in the intake air amount among the cylinders can be reduced.

Description Paragraph (58):
According to the embodiment for controlling the first and second type of the internal combustion engines, after reducing the variation in the fuel injection quantity among the cylinders in Step 105 shown in FIG. 11, when it is determined in Step 151 shown in FIG. 13 that the valve opening characteristics of the intake valve 2 are set such that the intake air amount to be introduced into the cylinder is limited by the valve opening characteristics of the intake valve 2, and not limited by the opening amount of the throttle valve 56, the process proceeds to Step 153. In Step 153, the exhaust gas air-fuel ratio of that cylinder is calculated and then in Step 250 and Step 251, the fuel injection quantity and the ignition timing, respectively, are corrected so as to reduce the variation in torque among cylinders.

Description Paragraph (59):
According to the foregoing embodiments and modifications thereof, after reducing the variation in the fuel injection quantity among the cylinders in Step 105 shown in FIG. 11, when it is determined in Step 151 in FIG. 13 that the valve opening characteristics of the intake valve 2 are set so that the intake air amount to be introduced into the cylinder is limited by the valve opening characteristics of the intake valve 2, and not limited by the cross-sectional area of the portion of the intake pipes 51 and 52 having the smallest internal circumference, the process proceeds to Step 153. In Step 153, the exhaust gas air-fuel ratio of that cylinder is calculated and then in Step 250 and Step 251 the fuel injection quantity and ignition timing, respectively, are corrected so as to reduce the variation in torque among the cylinders.

Description Paragraph (64):
Next in Step 104, a variation rate Qrate-n of the fuel injection quantity is calculated based on the variation .DELTA.Qn in the fuel injection quantity among the cylinders calculated in Step 103, just as was shown in FIG. 11. Then in Step 105, the fuel injection quantity of each of the cylinders Nos. 1 through 4 is corrected so as to reduce the variation in the fuel injection quantity among the cylinders, just as was shown in FIG. 11.

Description Paragraph (66):
Further, in the embodiments, when it is determined in Step 300 that the intake air amount to be introduced into the cylinder No. 1 when the exhaust gas air-fuel ratio thereof is calculated and the intake air amount to be introduced into the other cylinders Nos. 2 through 4 when the exhaust gas air-fuel ratios thereof are calculated are the same, the variation in the fuel injection quantity among the cylinders is reduced in Step 105 based on the exhaust gas air-fuel ratio. That is, after making the intake air amount in all of the cylinders the same, the fuel injection quantity is corrected such that the exhaust gas air-fuel ratios in all of the cylinders are the same. This allows both the variation in the air-fuel ratio among cylinders, as well as the variation in the torque among cylinders, to be reduced.

Description Paragraph (70):
Also, according to the foregoing embodiments and modifications, the variation among cylinders is able to be reduced based on the valve overlap amount of the intake valve 2 and the exhaust valve 3. More specifically, the variation in the fuel injection quantity among cylinders can be reduced based on the valve overlap amount of the intake valve 2 and the exhaust valve 3. Even more specifically, when it is determined in Step 300 in FIG. 14 that the valve overlap amount of the intake valve 2 and the exhaust valve 3 is set to the minimum value, the variation in the fuel injection quantity among the cylinders is reduced in Step 105. Therefore, when it is possible to change the valve overlap amount of the intake valve and the exhaust valve, the variation in the air-fuel ratio among the cylinders can be controlled more appropriately than when the variation among cylinders is not reduced based on the valve overlap amount of the intake valve and the exhaust valve. In other words, it is possible to appropriately control the variation in the air-fuel ratio among the cylinders.

Description Paragraph (71):
A routine according to the method for learning valve overlap amount variation, according to another embodiment and a modification thereof, in FIG. 15 is executed at predetermined intervals, just as the routine shown in FIG. 14. Referring to FIG. 15, when this routine starts, it is first determined in Step 150 whether the control in Step 105 in FIG. 14 has been completed. If the correction of the fuel injection quantity for all of the cylinders is not yet complete, it is determined that the variation in the valve overlap amount of the intake valve 2 and the exhaust valve 3 among the cylinders can not be reduced and the routine ends. If the correction of the fuel injection quantity for all of the cylinders is complete,

then the process proceeds to Step 450. In Step 450, it is determined whether the valve overlap amount of the intake valve 2 and the exhaust valve 3 is equal to or greater than a predetermined threshold value. That is, it is determined whether the valve overlap amount of the intake valve 2 and the exhaust valve 3 is set to a relatively large value such that the intake air amount to be introduced into the cylinder is limited by the valve overlap amount of the intake valve 2 and the exhaust valve 3, and not limited by the opening amount of the throttle valve 56. If the determination in step 450 is "NO", the routine ends. If the determination is "YES", the process proceeds to Step 152.

Description Paragraph (74):
According to the embodiment, after reducing the variation in the fuel injection quantity among the cylinders in Step 105 in FIG. 14, when it is determined in Step 450 in FIG. 15 that the valve opening characteristics of the intake valve 2 and the exhaust valve 3 are set so that the intake air amount to be introduced into the cylinder is limited by the valve opening characteristics of the intake valve 2 and the exhaust valve 3, and not limited by the opening amount of the throttle valve 56, the process proceeds to Step 153. In Step 153, the exhaust gas air-fuel ratio of that cylinder is calculated and then in Step 452, the variation in the valve opening characteristics of the intake valve 2 and the exhaust valve 3 among cylinders is reduced based on that exhaust gas air-fuel ratio. That is, after reducing the variation in the fuel injection quantity among the cylinders, the valve opening characteristics of the intake valves 2 and exhaust valves 3 of each of the cylinders Nos. 1 through 4 are changed such that the exhaust gas air-fuel ratio of the cylinder No. 1 and the exhaust gas air-fuel ratios of the other cylinders Nos. 2 through 4 are the same. Therefore, even if there is variation in the fuel intake quantity among cylinders, no variation in torque among cylinders is generated and the variation in the valve opening characteristics of the intake valves 2 and exhaust valves among the cylinders can be reduced.

Description Paragraph (75):
Also according to a modification of the embodiment, after reducing the variation in the fuel injection quantity among the cylinders in Step 105 in FIG. 14, when it is determined in Step 450 in FIG. 15 that the valve opening characteristics of the intake valve 2 and the exhaust valve 3 are set so that the intake air amount to be introduced into the cylinder is limited by the valve opening characteristics of the intake valve 2 and the exhaust valve 3, and not limited by the cross-sectional area of the portion of the intake pipes 51 and 52 having the smallest internal circumference, the process proceeds to Step 153. In Step 153, the exhaust gas air-fuel ratio of that cylinder is calculated and then in Step 452, the variation in the valve opening characteristics of the intake valve 2 and exhaust valve 3 among cylinders is reduced based on that exhaust gas air-fuel ratio. That is, after reducing the variation in the fuel injection quantity among the cylinders, the valve opening characteristics of the intake valves 2 and exhaust valves 3 of each of the cylinders Nos. 1 through 4 are changed such that the exhaust gas air-fuel ratio of the cylinder No. 1 and the exhaust gas air-fuel ratios of the other cylinders Nos. 2 through 4 are the same. Therefore, even if there is variation in the fuel intake quantity among cylinders, no variation in torque among cylinders is generated and the variation in the valve opening characteristics of the intake valves 2 and exhaust valves 3 among the cylinders can be reduced.

Description Paragraph (76):
More specifically, according to the embodiment and the modification thereof, after reducing the variation in the fuel injection quantity among the cylinders in Step 105 in FIG. 14, when it is determined in Step 450 in FIG. 15 that the valve overlap amount of the intake valve 2 and the exhaust valve 3 is set to the minimum value, the process proceeds to Step 153. In Step 153, the exhaust gas air-fuel ratio is calculated and then in Step 451, the variation in the valve overlap amount of the intake valve 2 and the exhaust valve 3 among cylinders is reduced based on that exhaust gas air-fuel ratio. That is, after reducing the variation in the fuel

injection quantity among the cylinders, the valve overlap amount of the intake valve 2 and the exhaust valve 3 of each of the cylinders Nos. 1 through 4 is changed such that the exhaust gas air-fuel ratio of the cylinder No. 1 and the exhaust gas air-fuel ratios of the other cylinders Nos. 2 through 4 are the same. Therefore, even if there is variation in the fuel intake quantity among cylinders, no variation in torque among cylinders is generated and the variation in the valve overlap amount of the intake valve 2 and the exhaust valve 3 among the cylinders can be reduced.

Description Paragraph (77):
In other words, according to the embodiment and the modification thereof, after reducing the variation in the fuel injection quantity among the cylinders in Step 105 in FIG. 14, when it is determined in Step 450 in FIG. 15 that the valve overlap amount of the intake valve 2 and the exhaust valve 3 is set to a predetermined valve overlap amount that is larger than the minimum valve overlap amount, the process proceeds to Step 153. In Step 153, the exhaust gas air-fuel ratio is calculated and then in Step 452 the variation in the intake air amount among cylinders is reduced with that exhaust gas air-fuel ratio. That is, after reducing the variation in the fuel injection quantity among the cylinders, the valve overlap amount of the intake valve 2 and the exhaust valve 3 of each of the cylinders Nos. 1 through 4 is changed such that the exhaust gas air-fuel ratio of the cylinder No. 1 and the exhaust gas air-fuel ratios of the other cylinders Nos. 2 through 4 are the same. Therefore, even if there is variation in the fuel intake quantity between cylinders, no variation in torque between cylinders is generated and the variation in the intake air amount between the cylinders can be reduced.

Description Paragraph (82):
According to the foregoing embodiments, after reducing the variation in the fuel injection quantity among the cylinders in Step 105 in FIG. 14, when it is determined in Step 450 in FIG. 16 that the valve opening characteristics of the intake valve 2 and the exhaust valve 3 are set so that the intake air amount to be introduced into the cylinder is limited by the valve opening characteristics of the intake valve 2 and the exhaust valve 3, and not limited by the opening amount of the throttle valve 56, the process proceeds to Step 153. In Step 153, the exhaust gas air-fuel ratio of that cylinder is calculated and then in Step 250 and Step 251, the fuel injection quantity and ignition timing, respectively, are corrected so as to reduce the variation in torque among the cylinders.

Description Paragraph (83):
Also according to the foregoing embodiments and modifications thereof, after reducing the variation in the fuel injection quantity among the cylinders in Step 105 in FIG. 14, when it is determined in Step 450 in FIG. 16 that the valve opening characteristics of the intake valve 2 and the exhaust valve 3 are set so that the intake air amount to be introduced into the cylinder is limited by the valve opening characteristics of the intake valve 2 and the exhaust valve 3, and not limited by the cross-sectional area of the portion of the intake pipes 51 and 52 having the smallest internal circumference, the process proceeds to Step 153. In Step 153, the exhaust gas air-fuel ratio of that cylinder is calculated and then in Step 250 and Step 251, the fuel injection quantity and ignition timing, respectively, are corrected so as to reduce the variation in torque among cylinders.

Description Paragraph (84):
Also according to the foregoing embodiments and modifications thereof, the variation among cylinders is controlled by the valve overlap amount of the intake valve and the exhaust valve. More specifically, when it is determined in Step 450 in FIG. 16 that the valve overlap amount of the intake valve 2 and the exhaust valve 3 is equal to or greater than a predetermined threshold value, the variation in the air-fuel ratio among the cylinders is reduced in Step 250. Therefore, when it is possible to change the valve overlap amount of the intake valve and the

exhaust valve, the variation in the air-fuel ratio among the cylinders can be controlled more appropriately than when the variation in the air-fuel ratio among the cylinders is controlled irrespective of the aforementioned threshold. In other words, it is possible to appropriately control the variation in the air-fuel ratio among the cylinders.

Description Paragraph (91):
Next in Step 504, a fuel injection quantity correction coefficient map, which shows the relationship between the fuel injection quantity correction coefficient and the operation angle of the intake valve 2, is created based on the fuel injection amount quantity correction coefficient calculated in Step 503 and the operation angle of the intake valve 2 at that time. As shown in FIG. 19, when a point P1 is calculated in Step 503, a curved line L1 showing the relationship between the fuel injection quantity correction coefficient and the operation angle of the intake valve is calculated from that point P1, and a fuel injection quantity correction coefficient map is created based on that curved line L1. According to a modification of the eighth embodiment, in Step 504 it is possible to calculate a relational expression that simplifies the curved line L1 instead of creating the map. Also according to a modification of the embodiment, it is possible to calculate not only the point P1 but also a point P1' in a step similar to Step 503, calculate a curved line similar to the curved line L1 based on the point P1 and the point P1', and then create a fuel injection quantity correction coefficient map based on that curved line.

Description Paragraph (94):
According to the embodiment or the modification thereof, a variation between cylinders is reduced by the operation angle of the intake valve 2. More specifically, as shown in FIG. 19, the variation in the fuel injection quantity among cylinders is reduced by calculating the fuel injection quantity correction coefficient of each cylinder No. 1 through 4 based on the operation angle of the intake valve 2, and correcting the fuel injection quantity in each cylinder No. 1 through 4 in Step 505 based on that fuel injection quantity correction coefficient. Therefore, when it is possible to change the operation angle of the intake valve, it is possible to control the variation in the air-fuel ratio among the cylinders more appropriately than when the variation between cylinders is not controlled by the operation angle of the intake valve.

Description Paragraph (96):
Also, according to the embodiment or the modification thereof, the variation in the air-fuel ratio among the cylinders is reduced by correcting the fuel injection quantity in Step 505 based on the operation angle of the intake valve 2. For example, when the air-fuel ratio of a cylinder varies to the rich side, the variation in the air-fuel ratio among the cylinders is reduced by correcting with a decrease the fuel injection quantity of that cylinder. Also, the smaller the operation angle of the intake valve, the greater the variation in the air-fuel ratio among cylinders when the actual operation angle is off from the target operation angle. In view of this, as shown in FIG. 19, the difference between the fuel injection quantity correction coefficient and 1.0 is made to become larger as the operation angle of the intake valve becomes smaller. As a result, the variation in the air-fuel ratio among the cylinders is controlled by increasing the correction amount of the fuel injection quantity. This enables the variation in the air-fuel ratio among cylinders to be controlled more appropriately than when the fuel injection quantity is not corrected by the operation angle of the intake valve.

Description Paragraph (102):
Next in Step 603, the target air-fuel ratio map showing the relationship between the corrected target air-fuel ratio and the operation angle of the intake valve 2 is created based on the corrected target air-fuel ratio calculated in Step 602 and the operation angle of the intake valve 2 at that time. As shown in FIG. 21, when a

point P2 is calculated in Step 602, a curved line L2 showing the relationship between the corrected target air-fuel ratio and the operation angle of the intake valve is calculated from that point P2. The target air-fuel ratio map is then created based on that curved line L2. According to a modification of the ninth embodiment of the invention, in Step 603 it is possible to calculate a relational expression that simplifies the curved line L2 instead of creating the map. Also according to another modification of the embodiment, it is possible to calculate not only the point P2 but also a point P2' in a step similar to Step 602, calculate a curved line similar to the curved line L2 based on the point P2 and the point P2', and then create a fuel injection quantity correction coefficient map based on that curved line.

Description Paragraph (105):
That is, when the corrected target air-fuel ratio shifts over to the lean side, for example, the feedback correction quantity is reduced such that the fuel injection quantity is corrected with a reduction. On the other hand, when the corrected target air-fuel ratio shifts over to the rich side, for example, the feedback correction quantity is increased such that the fuel injection quantity is corrected with an increase.

Description Paragraph (120):
The embodiment has substantially the same effects and advantages as the eighth and ninth embodiments. Moreover, according to the embodiment, in consideration of the possibility that a large torque variation may be generated if the correction amount of the fuel injection quantity is large, when it is determined in Step 700 that the calculated correction amount of the fuel injection quantity is small, the control apparatus individually corrects the fuel injection quantity in each of the cylinders Nos. 1 through 4 in Step 505, thereby minimizing the variation in the air-fuel ratio among the cylinders. On the other hand, when it is determined in Step 700 that the calculated correction amount of the fuel injection quantity is large, the correction amount of the fuel injection quantity is guarded by a predetermined value in Step 701. A corrected target air-fuel ratio is then calculated in Steps 602 and 603 and the fuel injection quantity of all of the cylinders Nos. 1 through 4 are uniformly corrected by that corrected target air-fuel ratio in Step 604. That is, air-fuel ratio feedback control is performed, such that torque variation is reduced while the air-fuel ratio is able to be appropriately controlled.

Description Paragraph (122):
According to the invention, by making the throttle valve opening amount in one cylinder when the exhaust gas air-fuel ratio of that cylinder is calculated and the throttle valve opening amount in another cylinder when the exhaust gas air-fuel ratio of that cylinder is calculated substantially the same, the intake air amount introduced into the one cylinder when the exhaust gas air-fuel ratio of that cylinder is calculated and the intake air amount introduced into the other cylinder when the exhaust gas air-fuel ratio of that cylinder is calculated are able to made the same. Furthermore, while a variation in the air-fuel ratio among cylinders can be reduced just as in the control apparatus for a multi-cylinder internal combustion engine disclosed in Japanese Patent Application Laid-Open Publication No. 6-213044, a pulsation generated by a variation in torque among cylinders when there is a variation in fuel injection quantity among cylinders can be avoided. That is, a variation in air-fuel ratio among cylinders as well as a variation in torque among cylinders can be reduced.

Description Paragraph (123):
According to an aspect of the invention, a variation in the intake air amount among cylinders can be reduced without generating a variation in torque among cylinders even if there is a variation in the fuel injection quantity between cylinders.

Description Paragraph (125):

According to another aspect of the invention, a variation in the operation angle of the intake valve among cylinders can be reduced without generating a variation in torque among cylinders even if there is a variation in the fuel injection quantity among cylinders.

Description Paragraph (128):
According to another aspect of the invention, a variation in the air-fuel ratio among cylinders can be controlled more appropriately than with the control apparatus for a multi-cylinder internal combustion engine disclosed in Japanese Patent Application Laid-Open Publication No. 6-213044, in which a variation among cylinders cannot be reduced based on the operation angle of the intake valve, when the operation angle of the intake valve can be changed. In other words, it is possible to appropriately control the variation in the air-fuel ratio among the cylinders.

Current US Cross Reference Classification (4):
701/103

CLAIMS:

1. A control apparatus for a multi-cylinder internal combustion engine including a plurality of cylinders, the control apparatus comprising a controller that detects a variation in an air-fuel ratio among the plurality of cylinders, and corrects a fuel injection quantity on the basis of the detected variation in the air-fuel ratio and an operation angle of an intake valve of each of the cylinders so as to reduce the variation in the air-fuel ratio when the variation is detected.

3. A control apparatus according to claim 1, wherein the controller corrects the fuel injection quantity on the basis of a relationship between a fuel injection quantity correction coefficient selected based on the detected variation in the air-fuel ratio and the operation angle of the intake valve of each of the cylinders so as to reduce the variation in the air-fuel ratio when the variation is detected.

4. A control apparatus for a multi-cylinder internal combustion engine including a plurality of cylinders, the control apparatus comprising a controller that reduces a variation in an air-fuel ratio among the plurality of cylinders by correcting a fuel injection quantity on the basis of an operation angle of an intake valve of each of the cylinders, wherein the controller: calculates a fuel injection quantity correction coefficient for reducing the variation in the air-fuel ratio when the variation in the air-fuel ratio among the cylinders is detected; calculates a relationship between the calculated fuel injection quantity correction coefficient and the operation angle of the intake valve obtained upon calculation of the fuel injection quantity correction coefficient; and updates the fuel injection quantity correction coefficient when the operation angle of the intake valve is changed on the basis of the changed operation angle and the calculated relationship.

6. A method of controlling a multi-cylinder internal combustion engine including a plurality of cylinders, comprising detecting a variation in an air-fuel ratio among the plurality of cylinders, and correcting a fuel injection quantity on the basis of the detected variation in the air-fuel ratio and an operation angle of an intake valve of each of the plurality of cylinders so as to reduce the variation in the air-fuel ratio when the variation is detected.

8. A method according to claim 6, wherein the fuel injection quantity is corrected on the basis of a relationship between a fuel injection quantity correction coefficient selected based on the detected variation in the air-fuel ratio and the operation angle of the intake valve of each of the plurality of cylinders so as to reduce the variation in the air-fuel ratio when the variation is detected.

12. A control apparatus according to claim 11, wherein the controller reduces a variation in an air-fuel ratio among the plurality of cylinders on the basis of the operation angle of the intake valve of each of the cylinders.

15. A method according to claim 14, wherein the method reduces a variation in an air-fuel ratio among the plurality of cylinders on the basis of the operation angle of the intake valve of each of the cylinders.

Previous Doc Next Doc Go to Doc#